1953.

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FIFTH ANNUAL REPORT

OF THE

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

FOR THE

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COMMONWEALTH OF AUSTRALIA.

Commonwealth Scientific and Industrial Research Organization.

FIFTH ANNUAL REPORT FOR THE YEAR ENDING 30TH JUNE, 1953.

I. INTRODUCTORY.

1. General.

The Commonwealth Scientific and Industrial Research Organization was established on 19th May, 1949, when the *Science and Industry Research Act* 1949 was proclaimed. Under that Act the Organization took the place of the Council for Scientific and Industrial Research, which in turn had, in 1926, taken the place of the Institute of Science and Industry.

The powers and functions of the Organization are similar to those of the former Council and include the initiation and carrying out of research in connexion with, or for the promotion of, primary and secondary industries in the Commonwealth or any Territory of the Commonwealth, or in connexion with any matter referred to the Organization by the Minister; the training of research workers; the making of grants in aid of pure scientific research; the testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization; the collection and dissemination of information relating to scientific and technical matters; and acting as a means of liaison with other countries in matters of scientific research.

2. Executive.

Mr. A. B. Ritchie, M.A., has been re-appointed as a part-time member of the Executive for a further period of three years.

3. Advisory Council.

The following changes have occurred in the membership of the Advisory Council:—

Sir Kerr Grant, Sir Harry Brown and Mr. W. S. Kelly have retired.

Professor M. L. Oliphant, Professor L. H. Martin, Mr. I. M. McLennan and Mr. Donald Mackinnon have been appointed as members.

Professor J. G. Wood has been appointed as Chairman of the South Australian State Committee in succession to Sir Kerr Grant.

4. Retirement of Mr. G. A. Cook.

During the year, Mr. G. A. Cook retired from the position of Secretary, after more than 30 years of service with the Organization and its predecessors. He first joined the Institute of Science and Industry in 1922, was appointed Assistant Secretary of the Council for Scientific and Industrial Research in 1927, and became Secretary in 1944.

Following the retirement of Mr. Cook, the Executive decided that the secretarial work will be the responsibility of four senior officers—

Mr. F. G. Nicholls—Secretary (General Administration).

Mr. G. B. Gresford—Secretary (Industrial and Physical Sciences).

Mr. W. Ives—Secretary (Agricultural and Biological Sciences).

Mr. M. G. Grace—Secretary (Finance and Supplies).

5. Retirement of Dr. F. L. Stillwell.

Dr. F. L. Stillwell retired from the position of Officer-in-charge of the Mineragraphic Section in June, 1953, after 26 years' service. He has been succeeded by Dr. A. B. Edwards.

6. External Territories.

Under its Act, the Organization is charged with responsibility for research of interest to the primary and secondary industries, not only of the Commonwealth, but also of Australia's external territories.

As a joint venture with the Papua–New Guinea Administration, eight Sahiwal, ten Sindhi and four Water Buffalo calves were flown from Pakistan during the year, and are at present in quarantine under close veterinary observation at Kila Kila, near Port Moresby. The animals will later be used for tropical beef and dairy cattle breeding investigations.

For the winter of 1953 the Land Research and Regional Survey Section has a survey team in the Buna Region of Papua. This team is organized on similar lines to those employed in northern Australia and where possible techniques developed in earlier land-use surveys will be employed. It is expected, however, that an initial period will be required for the development of special techniques for the surveying of this country. Assistance is being obtained from local authorities.

7. McIlrath Fellowship in Animal Husbandry.

Mr. William McIlrath, of Sydney, has given £50,000 to the Organization for the encouragement of research in animal husbandry. Mr. McIlrath's gift will be used for the establishment of a Senior Research Fellowship in animal husbandry.

8. Honours and Awards.

Mr. G. A. Cook, former Secretary of the Organization, was awarded the O.B.E. in recognition of his many years of service both to the Council for Scientific and Industrial Research and the present Organization.

Dr. O. H. Frankel, Chief, Division of Plant Industry, has been elected a Fellow of the Royal Society, in recognition of his contributions to the theory of plant breeding which have been published in some 35 scientific papers throughout his lifetime.

Dr. C. H. B. Priestley, Officer-in-charge of the Section of Meteorological Physics, was awarded the degree of Doctor of Science of the University of Cambridge. Dr. D. F. Stewart, Principal Research Officer, Division of Animal Health and Production, was awarded the degree of Doctor of Veterinary Science of the University of Sydney. Dr. T. S. Gregory, Principal Research Officer, Division of Animal Health and Production, was awarded the degree of Doctor of Veterinary Science of the University of Melbourne. Dr. R. C. Rossiter, Senior Research Officer, Division of Plant Industry, was awarded the degree of Doctor of Science of the University of Western Australia. Dr. D. F. Waterhouse, Principal Research Officer, Division of Entomology, was awarded the degree of Doctor of Science of the University of Sydney.

Dr. M. Blackburn, Senior Research Officer, Division of Fisheries, was awarded the degree of Doctor of Science of the University of Melbourne.

9. RESEARCH STAFF.

One of the most important functions of the Executive is the selection of research staff, since it is primarily on the quality of the men it appoints that the success of the Commonwealth Scientific and Industrial Research Organization's work depends. It is a constant concern of the Executive that it should continue to be able to attract the best men that the universities can produce.

The universities are now producing more graduates but the number of first-class men taking higher degrees in science and having proved ability for research is not increasing significantly, whereas the overall demand for research scientists in Australia has gone up considerably.

Unless the financial prospects offered by public and private employers to scientists are increased it will become more and more difficult to attract brilliant men into careers in science or technology. If the high standard of C.S.I.R.O. research is to be maintained it is necessary to meet normal replacements of scientific staff by recruiting each year a substantial proportion of the best graduates from the Australian universities, as well as obtaining a proportion of highly trained men from overseas. The Executive considers that, if it is to be able to do this satisfactorily in the future, it is an urgent matter that the question of the remuneration of specialists and highly qualified professional scientific men in both public and private employment should be examined as soon as possible.

10. BUILDINGS AND ACCOMMODATION.

Some progress has been made in the erection of new buildings, but many Divisions and Sections still find it necessary to carry on their work under crowded and difficult conditions. The new laboratory for the Division of Tribophysics in the grounds of the University of Melbourne is practically complete and the staff will take up their new quarters in the near future. A property for conversion for research work has been taken over during the year for the Wildlife Survey Section in Canberra. Work is still in progress on the buildings of the Sheep Biology Laboratory at Prospect, New South Wales; the Biochemistry Laboratory at Fishermen's Bend, Melbourne; the Wool Textile Research Laboratory, Geelong; the Central Block and the Microbiology Laboratory, Canberra; and the Perth Regional Laboratory.

11. NEW PUBLICATIONS.

A number of new publications has been issued by the Organization during the year and a full list of these appears in Chapter XXXII., Section 2.

The periodical *Rural Research in C.S.I.R.O.* established last year has received an excellent reception, and is proving a good medium for making the Organization's results in agricultural research available for extension services.

12. OVERSEAS VISITORS.

A number of leading scientists from overseas visited Australia in the year under review, many of them under the auspices of the Organization. In their visits to laboratories and establishments they gave much stimulus and help to Australian research workers.

Sir Ronald Fisher, D.Sc., F.R.S., Professor of Genetics at the University of Cambridge, visited Australia at the invitation of the Organization to consult with officers of the Section of Mathematical Statistics and other scientists concerned with breeding investigations.

Sir Edward Appleton, G.B.E., K.C.B., F.R.S., Principal and Vice-Chancellor, University of Edinburgh, headed a group of more than 50 distinguished scientists from over thirteen overseas countries who attended the Tenth General Assembly of the Union Radio-Scientifique Internationale held in Sydney in August, 1952.

Professor P. M. S. Blackett, F.R.S., Professor of Physics at the Imperial College of Science and Technology, London, visited Australia as the guest of the Australian National University and discussed a variety of subjects of scientific interest both with the Executive and research staff in a number of the Organization's laboratories.

Mr. A. Woodcock of the Woods Hole Oceanographic Institution visited the Division of Radiophysics to collaborate with Australian scientists on outstanding problems in cloud physics.

13. OVERSEAS VISITS, FELLOWSHIPS AND STUDENTSHIPS.

During the year under review, a number of officers of the Organization were sent overseas for some months to collect information on new developments in scientific research and to acquire general experience and training in new techniques. In addition, four senior officers were invited to visit overseas institutions for consultation concerning special aspects of their work.

This year the Organization altered its policy with regard to studentships, and instead of advertising general awards it invited applications for both Australian and overseas studentships in specific fields of physical and biological sciences. Five studentships and four traineeships were awarded to recent graduates for training overseas in fields which would enable them to fill specific posts in the Organization on their return to Australia. One studentship was also awarded from Science and Industry Endowment Fund moneys. At the close of the year 24 holders of studentships and traineeships awarded in previous years were receiving training in the United Kingdom, one in Holland, and three in the United States of America.

Ten studentships were awarded early in 1953 for post-graduate work in Australian universities, raising the total of those receiving training under this scheme to sixteen.

During the year several eminent overseas scientists have been invited to work with the Organization as Senior Research Fellows for periods of time ranging from six months to five years. To date four Senior Research Fellows have been appointed. One Textile Research Fellowship was awarded for training overseas in chemical problems related to the wool industry.

14. CO-OPERATIVE RESEARCH WITH INDUSTRY.

The Organization has continued to support the Australian Leather Research Association and the Bread Research Institute of Australia under a similar arrangement to that existing between the research associations in Great Britain and the Department of Scientific and Industrial Research.

A number of specific research projects are being undertaken in collaboration with individual firms. The Executive welcomes such opportunities for co-operation with industry and hopes that they may be extended.

15. COLLABORATION WITH UNIVERSITIES.

The establishment of research units within the universities is of great importance as it enables the Organization's officers to enjoy the stimulus and help of authorities in different fields of science. The Organization's work in the universities is mentioned in various places in the main body of this report.

Arrangements for collaborative work with universities are of three principal types. In some cases the Organization has established its own units in university buildings or has erected its own buildings on university roperty; in other cases, sections have been established) work in existing university laboratories with the rofessor acting as officer-in-charge. It has also been ɔund desirable, where the universities themselves can ndertake complete responsibility for specific research rojects, to provide funds to enable research workers to e employed by the universities.

The number of research workers involved in arrangeıents of these three types is now quite large, and the)rganization gratefully acknowledges its debt to the niversities, without whose co-operation many importnt research projects could not have been undertaken.

16. Science and Industry Endowment Fund.

During the year the Executive, as Trustees of the cience and Industry Endowment Fund, approved rants to assist research workers as follows:—Mr. 'arlton Rayment, for taxonomic work on bees; Dr. . Pearson, for work on comparative anatomy and nbryology of marsupials; Mr. F. W. Hely, for work ı soil fertility; Dr. B. Breyer, for polarographic work; r. R. W. Fairbridge, to join the Scripps Institute xpedition to the South Pacific; Dr. A. M. Clark, for ruit fly investigations; Mr. A. Bird, for entomological ıvestigations; Mr. V. D. B. Skerman, to attend the eeting of the British Commonwealth Collection of Iicro-organisms; Miss J. M. Langley, for work on ineralogy and petrology.

In addition, a studentship for overseas training in ıemotherapy was awarded to Mr. G. P. Warwick.

17. Finance.

Chapter XXXVI. gives details of expenditure uring 1952-53 by the Organization totalling 4,526,270. This amount includes a total of £1,044,392 erived otherwise than from the Commonwealth 'reasury, including £327,283 expended from the Wool ndustry Fund and £455,273 expended on wool producon and wool textile research from funds derived from ıe Wool Research Trust Account established under ıe provisions of the *Wool Use Promotion Act* 1945. ertain other expenditure involved in erection costs of uildings was also incurred on behalf of the)rganization.

The Organization is particularly gratified by the ay in which various bodies continue to support it, and y the marked interest evinced by certain sections of ıdustry which have provided donations for co-operative esearch. Among the many contributions received, eference may be made to those of the Commonwealth ank, Australian Wool Board, Australian Meat Board, ustralian Dairy Produce Board, Australian Wine oard, Australian Egg Board, the Queensland Meat ndustry Board, the New South Wales Department of griculture and New South Wales Water Conservaon and Irrigation Commission, the Metropolitan Ieat Industry Commissioners of New South Wales, the 'ictorian Railways, the George Aitken Pastoral esearch Trust, Burdekin Bequest, Ian McMaster equest, and Alexander Fraser Memorial Fund, the)ried Fruits Control Board, the Australian Dried 'ruits Association and the dried fruits industry, the 'ational Gas Association, Australian Institute of Iining and Metallurgy, Australian Cement Manufacırers' Association, the wool textile industry, the timber ıdustry, and the pulp and paper industry.

A statement has been included of expenditure on ontributions made by the Commonwealth to the 'ommonwealth Agricultural Bureaux, and the estabshment and maintenance of the Chair of Aeronautics t the University of Sydney, and on grants to the tandards Association of Australia, the Australian 'ational Research Council, and the National Associaon of Testing Authorities. The Organization is esponsible for the administration of the funds expended ı this way.

18. Organization.

For the purpose of carrying out its research work the Organization has established a number of Divisions and Sections. The Divisions, of which there are now fifteen, comprise the major establishments, which may be further subdivided into Sections; there are also independent Sections comprising establishments which have not reached a stage of development, so far as the scope and magnitude of their operations are concerned, to justify their designation as Divisions.

In the present Report an attempt has been made to group the material according to its subject matter rather than according to the Division or Section concerned. Additional chapters and appropriate cross references have been inserted, however, to permit the work of any particular Division to be reviewed as a whole.

As the Organization's investigations extend on a Commonwealth-wide basis and as many of the investigations which are being conducted—particularly those concerned with problems affecting the agricultural and pastoral industries—necessitate experimental work in the field, a number of branch laboratories and field stations have been established in various parts of Australia.

The Head Office of the Organization is in Melbourne and associated with it are the Organization's Central Library, Agricultural Research Liaison Section, and Central Experimental Workshops. The Organization also maintains Overseas Liaison Offices in London and Washington.

The Divisions which have been established (in order of their formation) are as follows:—

Plant Industry, with head-quarters and main laboratories at Canberra and field stations and experiment farms at Canberra, Australian Capital Territory, Lawes and Applethorpe, Queensland, Trangie, New South Wales, and Kojonup, Western Australia.

Entomology, with head-quarters and main laboratories at Canberra and field stations at Trangie, New South Wales, Rockhampton, Queensland, and Perth, Western Australia.

Animal Health and Production, with head-quarters in Melbourne and main laboratories in Melbourne, Sydney, and Brisbane, and field stations at Badgery's Creek, New South Wales, Cunnamulla, Amberley and Rockhampton, Queensland, and Werribee and Tooradin, Victoria.

Biochemistry and General Nutrition, with headquarters at Adelaide and field stations at O'Halloran Hill, Robe and Brecon, South Australia.

Soils, with head-quarters and laboratories at Adelaide, and branch laboratories at Perth, Canberra and Brisbane.

Forest Products, Melbourne.

Food Preservation and Transport, with headquarters and main laboratories at Sydney, branch laboratories in Brisbane, and minor laboratories at Gosford, New South Wales.

Fisheries, with head-quarters and main laboratories at Cronulla, New South Wales, laboratories in Perth and Melbourne, and field stations at Brisbane, Hobart and Thursday Island.

Metrology, Physics and Electrotechnology, comprising together the National Standards Laboratory, Sydney.

Radiophysics, Sydney.

Industrial Chemistry, with head-quarters and main laboratories in Melbourne and branch laboratories in Sydney, Adelaide and Perth.

Tribophysics, Melbourne.

Building Research, Melbourne.

The following are the Sections:—

Commonwealth Research Station (Murray Irrigation Areas), Merbein, Victoria.

Irrigation Research Station (Murrumbidgee Irrigation Areas), Griffith, New South Wales.

Radio Research Board, with head-quarters in Sydney and branch laboratories in Brisbane and Canberra.

Plant Fibre, Melbourne.

Ore-dressing Investigations, Melbourne and Kalgoorlie, Western Australia.

Mineragraphic Investigations, Melbourne.

Oenological Research, Adelaide.

Mathematical Statistics, Adelaide.

Dairy Research, Melbourne.

Atomic Physics, Melbourne.

Meteorological Physics, Melbourne.

Tracer Elements Investigations, Melbourne.

Coal Research, Sydney.

Physical Metallurgy, Melbourne.

Wildlife Survey, with head-quarters in Canberra and field stations at Perth and Albury, New South Wales.

Mathematical Instruments, Sydney.

Wool Textile Research Laboratories, with head-quarters in Melbourne and additional units in Sydney and Geelong, Victoria.

Land Research and Regional Survey, with head-quarters in Canberra and field stations at Ayr, Queensland, Katherine, Northern Territory, and Ivanhoe (Kimberley), Western Australia.

Agricultural Research Liaison Service, Melbourne.

Animal Genetics, Sydney.

In addition, Regional Centres (co-operative research units staffed with officers from the appropriate specialist Divisions to attack the problems of a particular district) have been established as follows:—

Regional Pastoral Laboratory, Deniliquin, New South Wales, with its associated Falkiner Memorial Field Station.

Regional Pastoral Laboratory, Armidale, New South Wales, with its associated field station, "Chiswick".

Tasmanian Regional Laboratory, Hobart.

Western Australian Regional Laboratory, Perth.

Plant and Soils Laboratory, Brisbane.

II. SOILS.

1. General.

A basic knowledge of the soil is fundamental to any proper land use, and improvements in farming method, more intensive cultivation, techniques for pasture improvement, and measures for soil conservation must stem from soil research.

The Organization's work in this field is undertaken by the Division of Soils with head-quarters at the Waite Agricultural Research Institute of the University of Adelaide. Some work on soils and their behaviour under irrigation is undertaken at the Commonwealth Research Station (Murray Irrigation Areas), Merbein, and at the Irrigation Research Station (Murrumbidgee Irrigation Areas), Griffith (*see* Chapter IV., Sections 2 and 3).

Division of Soils.—The Division does research into the classification, properties, and problems of Australian soils both of an applied and of a fundamental nature. The Division is the central and main body engaged in soil research in Australia, taking part either actively or consultatively in the very great bulk of investigations in this field. The primary objectives are—

(i) The systematic mapping of the soils of Australia in broad categories as an evaluation of national soil resources and as a comparative survey relating pedologically the soil groups of this and other countries.

(ii) The classification and mapping in varying degrees of detail of the soils of specific areas in regions marked for future or more intensive settlement or in which problems of production have arisen; this is a service of immediate value to the farmer and to State advisory and administrative bodies.

(iii) Applied research into problems concerning soil fertility or other chemical or physical factors affecting productivity.

(iv) Fundamental research on the pedology, chemistry, physics, and microbiology of Australian soils. This is becoming an increasingly important activity on which depends progress of applied research in the Division and also of investigations of other Divisions of the Organization and of outside agricultural authorities.

The Division operates as four closely linked sections—pedology and soil survey, soil chemistry, soil physics, soil microbiology. The work which is described in this chapter is decentralized at five regional centres outside of head-quarters in Adelaide, namely, Brisbane, Canberra, Deniliquin, Perth and Hobart. At three of these, Brisbane, Perth and Hobart, branch laboratories are already in existence and there is under construction a further large unit at Canberra.

The Division has co-operated continuously with the Waite Agricultural Research Institute, University of Adelaide, and has kept in touch with State and Commonwealth bodies interested in the research programme.

Recently a Conference in Soil Science was organized by the Division of Soils and the University of Adelaide. For seven days meetings were held at the Waite Institute, Adelaide. A total of 152 members attended from 47 organizations comprising Commonwealth and State bodies, universities, and secondary industry. The Conference was followed by a four-day field excursion to the south-east of South Australia and the western districts of Victoria. A small committee was set up to work out a system of soil classification acceptable to Australian pedologists generally and harmonizing the conflicting views expressed at the conference.

During the year officers have been overseas conferring with research workers and attending conferences.

2. Soil Survey and Pedology.

(Division of Soils.)

Survey work was carried on in all States and in north Australia, embracing a large number of separate units of work. Detailed surveys covered approximately 70,000 acres and broad-scale surveys about 50,000 square miles. A proportion of the work was concerned with land settlement of ex-servicemen. A good deal of the formal survey work, particularly in Western Australia and Tasmania, relates still to the development of crown lands, usually with problems in fertility. The Division is compiling a new soils map of Australia. Use is being made of new techniques of mapping and a more comprehensive system of classification—both developed since the last soil map of Australia was issued in 1943. The plan being followed in field work by the Division is to attempt the mapping of the soils in broad groups using as units the individual sheets of the international map of the world, scale 1:1,000,000. By this means an atlas of Australian soils will be built up and form a revised soil map of Australia. The field work of about half of the Melbourne sheet has been completed this year. This embraces eastern and central Victoria and the Monaro region in New South Wales. It is very desirable that work should be on as uniform lines as possible and to this end a *Manual of Australian Soils* was prepared and has now been issued.

(*a*) *Western Australia.*—Survey work in the past year has been concentrated both on detailed surveys and on the extension and revision of soil association mapping done the previous year. This embraces survey projects in the Mount Manypeaks and Stirling Range areas where land settlement is currently proceeding. The area covered during the year comprises 54,000 acres. The survey completed early in the year of another area of 25,000 acres north of the Stirling Ranges is of particular importance because of the possible hazard of salinity damage on certain soil types. Closer settlement is now reaching out on to such areas in Western Australia, and the solution of the salinity problem on non-irrigated land consequently assumes growing importance with such developments.

The Swan Valley plain near Perth, comprising about 20,000 acres, has been used at a very variable intensity and a number of problems have arisen, particularly with horticultural plantings. The detailed study of the soils and associated problems has been carried out over this area and the field work is now complete. Eelworm attack and zinc deficiency have both been demonstrated in the area and the problem remains to establish the relative importance of these and other features, such as restricted drainage, on the various soils mapped in the district. A considerable variety of soil types has been defined and these bear on the potential land use, which is clearly less intense than it should be in a favorable geographic and climatic situation. The basic data are now available for attacking problems in production and designing an improved system of land use into which the economic factor enters.

At the request of the Departments of Public Works and of Agriculture a reconnaissance survey with detailed mapping in some portions has begun over an area of 49,000 acres in the Boyanup-Capel district of the coastal plain. The area is being considered as an irrigation project using water from the Wellington Dam on the Collie River. Detailed surveys have been made on 4,500 acres in various parts of the project and it is hoped that with the aid of aerial photographs and the reconnaissance mapping the main characters of most of the area can be filled in. Field work will be continued with an assessment of irrigation value. On the coastal plain minor work included some intensive examination of small areas for experimental irrigation at Coolup near Pinjarra, where water of relatively high salinity is being used.

(*b*) *South Australia.*—The development of the low fertility lands occurring very extensively over the upper south-east of South Australia has directed surveys to the Keith district as a first step in the mapping and evaluation of this region. Building on to the early survey of 1933 south and west of Keith, and to the survey of 600 square miles in the County of Buckingham described in the 1951-52 Annual Report, the soil mapping of a further 300 square miles is complete on one additional area and approaching completion in another where settlement is rather longer established. This latter is the Tatiara district, which comprises the westward extension of the Wimmera of Victoria into South Australia. The total area covered by all these surveys is a continuous block of about 1,600 square miles.

The detailed survey of the second of five units in the Barossa district has proceeded and a further 12,000 acres is mapped. There is a rather different set of soil formations to the type covered in the previous unit. It is also horticultural, grazing, and mixed farming land with specific problems. The survey is less intensive in general than the earlier one, with some portions mapped in close detail. The third unit, in the Tanunda centre, has been begun. There are major problems in land use, particularly the reconstitution of degenerated horticultural farms and improved production of pastures. An area of approximately 3,000 acres situated on Lake Alexandrina near Wellington has been surveyed with a view to its development as a post-war settlement, partly by irrigation from the lake. This is but part of a wider regional problem associated with the economic use of the waters of the lake. Unfortunately the area surveyed has a preponderance of saline soils. The survey of 10,000 acres at Mintaro began as a collaboration with the Waite Research Institute which is planning to establish experimental work in agronomy on selected portions. The survey is mainly completed. It should form an excellent basis for pasture research when all the data, field and laboratory, are assembled.

Additional examinations have been made by further spot-surveys in the Adelaide hills district as a beginning of a more comprehensive soil map. The foothills and plains area is also being studied as an extension of the part covered by the investigation of soils and housing in Adelaide suburban areas.

(*c*) *Victoria.*—Apart from broad-scale regional mapping mentioned above and a reconnaissance of the soils of the Wimmera and adjacent districts no other soil survey work has been undertaken in Victoria during the year.

(*d*) *Tasmania.*—Over the past seven years field work of varied detail has proceeded over the region described as the Launceston Basin. The surveys have now been carried to a final stage. The Basin area is a most interesting district pedologically, and agriculturally is capable of more intense development. The development of river terraces has been studied as an aid to understanding the soil pattern.

The survey of the whole of Flinders Island has now been completed, together with an intensive mapping of 4,000 acres in representative areas. The relationships of soils to geomorphology in this island are of great interest, portion of it apparently representing a very old land surface while much of the remainder is very young, consisting of dune systems and raised beaches. The provision of a suitable base map by photogrammetry is being arranged with the National Mapping Section of the Department of the Interior.

Progress has been made with the project of mapping the soils of Tasmania in broad groups. A commencement was made near Hobart using military index sheets as geographical units. The greatest handicap in the future will be the lack of suitable base maps for both field work and compilation of soil plans, but the areas so far undertaken have fortunately had excellent military maps. Compilation of maps for other areas is being based on air photo co-ordination.

The Frodsley Estate in the South Esk Valley has been the subject of earlier investigations and a good deal of associated research by other bodies. The stock-carrying capacity has been raised considerably in past years with superphosphate and subterranean clover, but last winter the pastures failed and losses were heavy. The Division has co-operated in a programme of Commonwealth and State bodies by a new survey of 3,000 acres of improved pasture land. This survey has yielded information of value to experimental work and allowed the selection of appropriate sites for field plots and studies in animal nutrition. Further areas totalling 120 square miles adjacent to the Launceston Basin have been mapped in broad categories. Time was also devoted to a field study of alpine soils which are quite extensive in Tasmania.

(*e*) *Irrigation Zone.—New South Wales and Victoria.*—The principal detailed survey has been in the Jernargo area west of Jerilderie, New South Wales, which is proposed for more intensive development extending from the older Berriquin Irrigation District. Approximately 8,000 acres were so mapped and a further 120,000 acres in a broad-scale association survey. A beginning was made with the survey of the

Murrumbidgee Irrigation Areas of which the horticultural section only had been covered in a survey twenty years ago. The New South Wales Department of Agriculture Soil Survey unit is co-operating actively in all this work. Broad-scale mapping has extended mainly north and west and with particular attention to the large area west of the Murrumbidgee Irrigation Areas between the Lachlan and Murrumbidgee Rivers with an area of 3,000 square miles. This district has been under review as to the possibility of its intensified development with Snowy Mountains water when it becomes available in a few years. An officer has been serving on the New South Wales Committee dealing with the use of Blowering Dam water from the Snowy Mountains scheme and considerable effort is being directed towards the assessment of the soil factor as the key to development. The work is closely tied in with engineering investigations. Attention is being directed towards the salt and cation régime in the soils of the region, especially towards a better prediction of the soils' ultimate development under irrigation. A two-year programme of soil salinity investigations has been commenced. Attention is being given to the calcareous crumbly soils of the region, as it appears these may have a unique part in the future irrigation of the area.

(*f*) *New South Wales and Australian Capital Territory.*—The broad survey of the Southern Tablelands has been carried northward to include the Canberra and Goulburn 4-mile military sheets comprising 11,000 square miles. About three-quarters has been completed, together with eleven spot surveys in detail to examine and define the soil pattern. The land-use map of the Australian Capital Territory has been completed except for a small area in the north and three detailed spot surveys. Erosion status has been included as a feature of the Australian Capital Territory work. Following earlier surveys along the Macquarie and Bogan Rivers in the north-west of New South Wales, a third area near Warren was examined for the Irrigation Commission. This totalled 600 square miles. A further unit is yet to be mapped to give a soil picture of an almost continuous belt of the plains country commandable for irrigation from the Burrendong Dam. The limited water supply available has enforced a rigid examination of the soil-irrigation potential.

(*g*) *Queensland.*—Work has been concentrated on the study of the soils of part of the Darling Downs. The current project involves field and laboratory studies and soil mapping over an east-west strip across the centre of the Darling Downs between Toowoomba and Cecil Plains. Its main aims are (1) detailed study of the properties, classification, and relationship to agricultural use of the black earth soils, (2) study and pedogenic interpretation of the patterns of red and black soils derived from basalt rock in the upland areas, and (3) the mapping of soil associations of significance to use at the farm unit level.

During the year field work for five additional detailed spot surveys in the Middle Ridge, Southbrook, Cecilvale, Aubigny, and Bongeen areas was completed, defining soil patterns as a basis for the soil association mapping. The aggregate area now covered by detailed survey is 40,000 acres, but several more small spot surveys will be necessary, particularly on the Kurrawa 1-mile military sheet. The broader-scale soil association mapping is now in progress on the area covered by the Toowoomba 1-mile military map sheet. In addition to the deep, red lateritic and non-lateritic soils of the Toowoomba area, slightly acid to alkaline red soils of moderate depth and morphology related to the red-brown earth group have been described forming patterns with the very dark to black clay soils of the western part of the upland basaltic area. A number of profiles selected as representative of the soils of the coastal area north of Brisbane were studied and sampled for laboratory analysis, at the request of the Division of Plant Industry. These soils have been identified as members of four great soil groups—relict sandy lateritic soils, groundwater podzols, low humic gleys, and humic gleys—and are now being subjected to detailed laboratory examination (*see* Chapter III., Section 18).

(*h*) *North Australia.*—An officer has been seconded as pedologist to the North Australia survey unit of the Land Research and Regional Survey Section. The pedological work of these surveys is correlated by the Division of Soils. The work completed this year is in the Ord-Victoria River Region comprising 70,000 square miles. The survey of a similar large unit in the Gulf country of north Queensland is just beginning. The work is co-ordinated on the pedological side by a visit from head-quarters during the field work. All analytical work on soil samples is conducted in the Division's laboratories. An officer of the Division of Soils is also associated with the New Guinea unit of the Land Research Section. These surveys are described in Chapter XI.

3. SOIL PHYSICS.

(Division of Soils.)

(*a*) *Water Movement in Unsaturated Soil.*—Most practical problems relating to soil water in Australia involve unsaturated rather than saturated conditions over a wide range of alternating wetness and extreme dryness. On the other hand, it is the saturated condition that in the past has been more widely studied, particularly overseas. The Division is therefore conducting work on the mechanism of water movement in unsaturated soil. Results obtained on movement under a temperature gradient have been published. They show that, in a closed system, water will move in the vapour phase toward the cool end of the system and in the liquid phase in the reverse direction. In this work, the movement of chlorides in solution served to distinguish between liquid and vapour movements. The same technique has now been applied to a study of the movement of water in relatively dry soil. It has been found that water moves as a liquid in soils which are as dry as the wilting percentage. This has led to the conclusion that water movement in soil plays more part in the supplying of water to plant roots than has hitherto been supposed. Other implications in relation to water availability, salt distribution through soil profiles, and movement of water under engineering structures are being studied. Attention has been given to the negative adsorption of chloride ions from soils in connexion with the unsaturated permeability studies.

(*b*) *Vapour Losses from Pressure Membrane Apparatus.*—The pressure membrane apparatus is standard equipment in the laboratory for the measurement of water content of soil in relation to soil water tension. Loss of vapour through the cellophane membrane of the apparatus would affect this measurement. The extent to which this can occur has been measured at a range of pressures and it is concluded that this type of loss is unimportant. However, losses occurring from other parts of the apparatus may be significant and it is suggested that at the commencement of each run the apparatus be brought up to pressure and then the gas cut off at the source. The loss of gas in the first day may then be used to check these leaks.

(*c*) *Physical Properties of Soils.*—Various properties of soils which affect its behaviour in agricultural usage are being studied with the objective of setting up a limited number of methods to be applied in the routine examination of soil. These methods include structure stability, pore size, and range of available water. It is hoped that a useful means of characterizing the physical status of soil will arise from this work. An attempt is being made to standardize these methods to make them suitable for routine use.

(*d*) *Stability of Structure.*—When soil aggregates are wetted they often tend to slake down to an unstable mass. The stability of these aggregates is an important feature on which the maintenance of good tilth depends. One cause of breakdown is the explosive action of entrapped air compressed by water soaking into the aggregate. Work is proceeding on this, and it has been found that the degree of breakdown of aggregates on wetting depends on the water content of the soil, before it is wetted. Moist soils break down less readily than dry soils when they are flooded with water. Similarly and for the same reason soil from which air has been evacuated is more stable when wetted than soil wetted under atmospheric pressure. The effect of concentration of electrolyte on permeability and on the stability of structure has been studied by an officer of the Division during the tenure of a studentship overseas. This work has quantitatively evaluated the level of electrolyte required to keep the soil colloids in a flocculated condition when the soil is saturated to varying degrees with sodium. In another section of this work the permeability of montmorillonite to strong solutions of electrolyte has been used as a measure of swelling. It has been shown by X-ray measurements that the loss of permeability of sodium montmorillonite can be attributed to crystalline swelling beyond 20 Å. In a general way the permeability of the Na- and Ca-montmorillonite has been connected with the X-ray spacing by the use of the Kozeny porosity factor.

(*e*) *Structure.*—Further tests on the effect of crop rotations on physical properties of soils have shown that, in plots where conditions were such that structural breakdown throughout the growing season was a minimum, a significant difference in bulk densities still existed between those under four-course and two-course rotations (*see* 1951-52 Annual Report). Water stability tests of these soils showed a significantly higher stability in that under the four-course rotation. Plots of the same soil type, which were in the second and sixth years of pasture as part of their rotations, showed a considerably greater water stability than the four-course which included only one year of pasture. No difference was obtained between the stabilities of either of the plots under longer pasture.

(*f*) *Soil Conditioners.*—Tests with soil conditioners have shown that these greatly increase the water stability of an unstable soil. Where oats were grown in a subsoil in pots under ideal conditions of moisture and nutrients, only slightly increased yields were obtained in the treated soil but root development in the latter was several times as great as that in the untreated soil.

(*g*) *Formation of Surface Seals on Soil.*—The effect of raindrop action on the "sealing" of the surface soil is being studied both in the field and in the laboratory. A small rain simulator has been developed for examining the effect of raindrops on soil under controlled conditions. A large simulator is necessary if field conditions of splash are to be duplicated. In the meantime the mechanism of seal formation and the effect of seals on soil properties and soil-air-water relations are being investigated in the field.

(*h*) *Seasonal Changes in Water Content and Movement of Clay Soils.*—Field studies of the seasonal change of water status of the soil profile are continuing in Adelaide. At the same time the vertical movements of the soil resulting from changes in water content are being measured. The maximum depth of the seasonal penetration of rain and the progress of drying in the soil profile have been determined for the Adelaide climate and typical soil environments. Water penetration of the order of 10 feet has been noted in red-brown earth soils by the late winter. Soil water changes and earth movements have been correlated. As a consequence definite recommendations can be given concerning the appropriate footings for houses which must be built on these "troublesome" soils. The amount of water seasonally stored in the soil profile has been measured at a number of sites in Adelaide and found to be 8·9 inches in a normal red-brown earth profile. This storage has been compared with the amount estimated from the annual sum of precipitation corrected for evaporative losses according to various formulae.

(*i*) *Swelling of Clay Soils.*—Laboratory work on soils liable to extensive volume change is being undertaken. The change in volume accompanying changing water content and soil water tension has been measured on remoulded clay blocks. The water content-volume relation is unique but considerable hysteresis is evident in the relation between soil water tension and water content (or volume), according to whether the final equilibrium water content is reached by drying or wetting the soil.

(*j*) *Measurement of Soil Water Status in the Field.*—New devices are being developed in an attempt to improve on other methods being used by the Division to obtain an *in situ* measurement of water content or soil water tension. One of these uses the volume change of clay as its principle. The other depends on the slowing and scattering of neutrons by hydrogen.

(*k*) *Examination of Soils for Engineering Purposes.*—The survey of the soils of Adelaide suburbs carried through in previous years has now been prepared for publication, together with a discussion of their engineering properties. A generalized map of the soils and a description of their characteristics and behaviour are provided. Colour photographs of soil profiles will assist in their identification by the architect or builder concerned with selecting a type of foundation suited to a particular soil. This publication is being put out in conjunction with the Department of Mines, South Australia, which has assumed responsibility for an advisory service relating to soils and house foundations for private inquirers. The Experimental Building Station of the Department of Works is concerned with the design of foundations appropriate to the various soil types. A similar survey has been conducted on soils on basalt in the suburbs of Melbourne. At the request of the Gas and Fuel Corporation of Victoria an examination was made of soil conditions along the route of a proposed pipe line from Morwell to Melbourne in Victoria. The route included an area subject to landslides which had become dangerous during the wet winter this year. Recommendations regarding alternative routes and possible treatments were made and were adopted. Upon a request from the Architect-in-Chief's Department, South Australia, the soils of the Northfield Mental Hospital area were examined. A report has been made on soil strength and water content conditions as they affect the design of large extensions to the hospitals where the soils are of a problem nature for foundation structures.

(*l*) *Mineral Studies.*—A detailed study is being made on the soil colloids extracted from the terra rossa and rendzina soils. These colloids are usually high in illite, with kaolin and free iron oxide present in smaller amounts. Further work has shown that these colloids and those from the red-brown earth soils are essentially crystalline, although it was previously thought that they contained considerable amorphous matter. Colloids from solodized solonetz soils are also being studied, together with a few samples from Kangaroo Island, Tasmania, and New South Wales.

Some soil colloids from south of Adelaide are rich in "opal". The rock underlying these soils is almost pure "opal". This "opal" gives a diffraction pattern which is very similar to that of many common opals, the precious opals being often truly amorphous. The diffraction pattern given by the "opal" resembles, in an approximate way, that of β-cristobalite. It is considered that the material or its diffraction pattern cannot be satisfactorily accounted for by β-cristobalite, so work is continuing in the hope of elucidating its structure and origin. Some time has been spent in improving standard data available for X-ray analysis. The A.S.T.M. cards have had data punched on them and data obtained from the literature has been added to the index, particular attention being paid to silicas, silicates, phosphates, and manganese oxides. Work has continued on the X-ray spectrograph and experiments indicate that it is suitable for detecting elements of greater atomic number than potassium. Under favorable circumstances one part in 10,000 can be detected. A comparative study of the mineralogy of the black soils and krasnozems which occur at Lismore, New South Wales, has been completed. These two soils are very different in the field and in their mineralogy, the red soils being mainly kaolin with free oxides while montmorillonite was dominant in the black soils. The mineral studies indicated that the two soils, which occur side by side on basalt, represent different stages in the one weathering process. This study is now being extended to krasnozems from other parts of Australia.

An investigation into the structure of cookeite was also undertaken. Cookeite has a chlorite structure but is unusual in containing no iron or magnesium. Aluminium with a little lithium occupies the octahedral positions.

A study of the crystalline swelling of montmorillonite on wetting showed that the lattice swelling continued beyond 20Å for monovalent cations although previous work had generally assumed this as the limit. Up to 20Å the interlayer swelling was stepwise. It then jumped to 40Å after which it progressed continuously. Spacings up to 150Å were measured and the indications were that the crystal swelling did not cease at this point. All the swelling of montmorillonite can be accounted for by the crystal swelling. These investigations were carried out by an officer working at the Rothamsted Experimental Station in England from which he has now returned. With other members of the Pedology Department at Rothamsted an investigation was made into the esters and silanes of montmorillonite. No evidence was found supporting the existence of these compounds. These organic complexes behaved like normal, adsorption complexes of montmorillonite.

(*m*) *Soils in Relation to Irrigation Development.*—The characterization of the physical properties of soils from the Lower Burdekin Valley has been completed at the Brisbane Regional Laboratory. A statement dealing with the water entry characteristics of the soils has been published and gives details of the expected behaviour under irrigation culture. The laboratory characterization is being summarized to form a supplementary report on the general physical properties of the soils of the area. Consideration has been given to the use of laboratory measurements in rating soils for their adaptability to development. An index has been devised based on five physical criteria to assess the status of the soil and its expected influence upon agricultural potential. To date the index has only been used on a limited group of soils, but it appeared to separate them into definite groups. The index is only designed to rate the soil on its physical status, and is not intended as a complete assessment of the agricultural worth of the soil, as it takes no account of chemical or economic factors. A good deal of attention has been paid to standardizing the laboratory measurements used in determining physical properties. An adequate laboratory procedure has been established and the methods investigated in some detail. A study has been made of shrinkage of natural soil aggregates accompanying progressive water withdrawal. The influence of soil properties on the extent and character of the shrinkage has been assessed. In particular the influence upon water entry of this shrinkage and subsequent crack formation in field soils has been examined.

4. SOIL CHEMISTRY.

(Division of Soils.)

(*a*) *Micro-nutrient Investigations.*—The work on soil manganese has been continued by the laboratory study of various extractants capable of forming complex anions with divalent and trivalent manganese. In a pot experiment a manganese deficient soil was treated with three levels of manganese sulphate and then sown with oats. After harvesting the manganese has been well recovered from the soil by extraction with an acetate buffer of pH 7-8 containing quinol and "Sequestrene" (ethylenediaminetetraacetic acid) but, in the absence of either of these two compounds, the recovery dropped sharply. A 1 per cent. potassium cyanide solution of pH 8.5-9 has also been found to extract the greater part of the manganese from some soils. The conditions of extraction employed have prevented peptization of large amounts of organic matter and lessened the risk of reduction of oxides of manganese during extraction. As the results of the above work indicated that added divalent manganese had been oxidized, tests were made on the recovery of manganese sulphate added in the laboratory to various soils. No evidence of oxidation was found in samples which had been kept air dry for 48 hr and other samples are being kept for longer periods. Further tests on the extraction of known compounds of manganese added to soils should allow a fuller assessment of the significance of the results obtained with the above reagents.

(*b*) *Ion Exchange and pH Studies.*—The investigation of the ion exchange-pH relationships in various cation-dominant soils is nearing completion. For the pH determinations soil water suspensions have been used and the ratio of soil to water has been such that unit volume contained a constant number of exchange positions. As the amount of sodium held in exchange positions increases, hydrogen being virtually the only other competing ion, the pH increases at a slower rate for kaolinitic soils than for soils containing montmorillonite or illite as a major clay mineral constituent. Illitic soils give a higher pH than montmorillonitic soils, with the same exchangeable sodium, by as much as four units. As the potassium in the exchange positions increases, there is a difference of two to three units between the pH of montmorillonitic soils and other soils having the same exchangeable potassium content, the montmorillonitic soils having the lower pH. Montmorillonitic and illitic soils increase their pH with increasing exchangeable calcium at a slightly faster rate than the kaolinitic soils, but in general the differences shown are not large. For montmorillonitic soils the overall effect of potassium is very similar to that of calcium and the combination of these two gives pH values of the order of one unit lower than for the same exchangeable sodium content. The effect of exchangeable magnesium in competition with hydrogen is very different from that of calcium; for the same amount of magnesium on the soil, pH values are more than two units higher than for calcium. Magnesium soils of all the mineral types studied give similar pH values except for those soils containing large amounts of free iron oxide which give a slightly lower pH.

(*c*) *Cation Exchange and Clay Properties.*—Investigations have commenced into methods of determining exchangeable cations in soils, particularly in calcareous ils, and some progress has been made in developing a aching solution which can be used without radical odification of existing analytical procedures. In rder to test this and other methods bulk homoionic soil amples are being prepared. A simple ultramicroscope as been assembled for use in preliminary work on the eversal of charge phenomena in soil colloids.

(d) *Terra Rossa and Rendzina Soils.*—This project eeks to account for the formation of these morphoogically different soils on apparently similar parent aterial and under the same climatic conditions. The boratory investigation has been conducted in two ages; the first was to determine which, if any, chemical aracteristic or combination of characteristics could ifferentiate between these two soils; the second, from an xamination of the underlying calcareous material, ought to account for this difference. It has been found at these soils may be differentiated on the basis of the atio of free ferric oxide to nitrogen in the clay fraction. Vhere this ratio is less than ten the soil is a rendzina, here greater than ten a terra rossa. The study of the nderlying calcareous material is nearing completion, ut indications are that there seems little prospect of is factor accounting for the formation of these two roups of soils.

(e) *Spectrochemical Investigations.*—All the samples connexion with the factorial experiment designed to etermine the influence of the three major components of lant ash (potassium, calcium and silicon) on emission y the minor components have been arced but the xamination of plates have been deferred pending the eturn of the officer concerned from overseas. As part of detailed study of the lateritic soils of Western Ausalia work has started on the spectrochemical analysis f 140 samples of gravel and fine earth from thirteen rofiles. Increasing demands are being made for specochemical examination of samples other than soils or lants; during the year the miscellaneous samples cluded fish scales from healthy and unhealthy fish, heelite samples from the Bureau of Mineral esources, radioactive and other minerals from the outh Australian Department of Mines, and minerals om other sections of the Division.

(f) *General Soil Analysis.*—Laboratory examination soil samples collected by the Soil Survey Section and hers continues to be a large and important part of the ork. A new method for the removal and determinaon of free iron oxide in soils has been used successfully d faster methods for determination of total exchange pacity of soils are being investigated. The demand r the determination of both soluble and exchangeable ations in soils has increased considerably and the use the flame photometry attachment No. 9200 with the eckman DU spectrophotometer is under investigation. the meantime, an accurate assessment has been made the errors involved in the use of the Lundegardh air etylene flame technique for the determination of lcium, magnesium, potassium, and sodium in solutions ontaining various combinations of the four cations.

(g) *Chemical Analysis and Mineralogical Work.*—A etailed chemical and mineralogical study has been ade of profiles of a number of the clay pit series of ils in the Barossa Valley, South Australia. The reater part of the subsoil samples consisted of very niform-sized grains of quartz that showed considerble etching probably due to alkaline conditions. Illite well as kaolin was present in the clay fraction. Work as commenced on a comprehensive chemical study of e illitic type of clay mineral that occurs extensively Australian soils.

(h) *Rainwater Studies.*—Equipment has been esigned in polythene to extract both cations and anions om rainwater by the use of exchange resins.

(i) *Miscellaneous Investigations.*—Work is in progress at the Brisbane Regional Laboratory on a modification of the rapid Passon method for the determination of free carbonates in soils with a view to its adoption as a routine method in laboratory studies. Studies on the zinc status of the black earth soils have been continued with special emphasis on a method for the determination of zinc in soils in the presence of cobalt and copper. Studies are now being extended to the fractionation and determination of zinc content of a wider range of soils. The study of the equilibrium levels of mineral nitrogen under grass in the black earths of the Darling Downs is being continued. Mineral nitrogen levels in the field were generally low, with a trend to a maximum in summer. The work is being extended to soils in continuous fallow, as well as soils under grass, samples being taken both from the surface and at depth. Some preliminary experiments on the rate of nitrification of added ammonia-N, using the Quastel and Lees perfusion technique, have been carried out.

The work on the chemistry and mineralogy of the lateritic soil derivatives in Western Australia has continued at the Perth Regional Laboratory on the thirteen representative profiles previously sampled. Considerable progress has been made with the study of the clay mineralogy which is being covered by the X-ray section of the Physics Department of the University of Western Australia. The examination of atmospheric salt accession to three inland centres, Dwellingup, West Pingelly, and Kojonup, has proceeded for a further year. Regular analyses of the rainfall have shown that the amount received at Kojonup, 90 miles from the coast, is approximately half that received at Perth, four miles from the coast. The composition of the rain varies considerably from sea-water in calcium content, as suggested by some earlier work by the Division. The rain analyses are continuing for a further period with modifications in collecting technique. The use of synthetic ion exchange resins for extracting anions and cations from rainwater has proved reasonably successful but the technique requires perfecting.

5. SOIL MICROBIOLOGY.

(Division of Soils.)

(a) *Trace Elements and Microorganisms.*—Bioassays of fifteen rocks and 65 minerals were made for the amounts of iron, zinc, copper, manganese, and molybdenum available to *Aspergillus niger* (Mulder's strain). The micronutrients most commonly released were iron and molybdenum, followed by manganese then copper, and least of all zinc. Among the minerals, those featuring micronutrient elements in their chemical formulae tended to be fairly good sources of these elements, but certain minerals not suspected of containing micronutrient were also found to provide them in moderate amounts. Despite widespread belief, the ferro-magnesian minerals are not always good sources of available micronutrients.

Theoretically the fungus *Curvularia* which produces no organic acids should be a closer approximation to a higher plant than the mould *Aspergillus niger* which produces large amounts of acids. In comparative studies, however, both give similar bioassay results. This suggests that exchange of hydrogen ion for trace metal cations is not the mechanism whereby moulds acquire micronutrients. Further studies have shown that contact between hyphae and soil is not necessary except in calcareous soils where both fungi have difficulty in acquiring iron and manganese adsorbed on calcium carbonate. A reducing substance, such as ascorbic acid, or a non-toxic chelating agent, such as disodium ethylenediamine-tetraacetate ("Versene"), assist both moulds to obtain iron and manganese.

In attempts to develop bioassay methods for available boron and cobalt, no small organisms were found which showed deficiency symptoms except the alga *Chlorella vulgaris* and the floating aquatic plant *Lemna minor* for boron. Smaller amounts of vitamin B_{12} were synthesized by microorganisms in cobalt-deficient soil than after the addition of cobalt. None of these organisms was satisfactory for bioassays so this work was abandoned.

Using a macro-respirometer developed in this laboratory, studies have been made of the influence of deficiencies of macro- and micronutrient upon soil microbial respiration. Deficiencies of nitrogen and phosphorus markedly reduce both oxygen uptake and carbon dioxide output, lack of sulphur reduces respiration appreciably, deficiencies of potassium and magnesium have slightly adverse effects, but gross deficiencies of calcium and of trace elements have no effect—suggesting that most soil microorganisms gain adequate amounts of micronutrients even from the most deficient soils. The fixation of phosphates by clays and by compounds of iron, aluminium and calcium and the liberation of phosphorus from various phosphatic fertilizers and organic phosphates is being studied with the respirometer.

(*b*) *Subterranean Clover—Rhizobia—Rhizosphere Interrelationships.*—Factors affecting the growth of strains of *Rhizobium trifolii* in the rhizosphere of subterranean clover have been investigated. Some strains of rhizobia applied to the seed coat in the manner of commercial inoculation are able to form effective associations with the subterranean clover plant when sown in pots of sterilized soil in the green house, but under natural conditions in unsterilized soils such strains are unable to establish themselves in the soil in the face of competition from the indigenous microflora. The plant then shows symptoms of nitrogen deficiency in the absence of effective nodulation. Where a number of strains of rhizobia, either inoculated or indigenous to the soil, are competing for sites of nodule formation, some are more successful in their ability to produce nodules than others. In selecting strains of *R. trifolii* for purposes of commercial inoculation, it is essential to select those which are well adapted to a saprophytic existence in the soil and which will readily proliferate in the rhizosphere under the influence of root excretions. Those which readily establish themselves from the inoculum carried on the seed and can maintain a saprophytic existence in the soil over the summer period in the absence of the leguminous host have been termed "incursive" strains. An empirical test for incursion has been developed by simultaneously inoculating a strain known to be efficient in its power of nitrogen fixation with one known to be inefficient. The resultant plant reaction indicates which of the two is the more incursive. Field evidence of the importance of incursion as a property of rhizobia has been obtained from the failure of some strains to symbiose with subterranean clover sown from inoculated seed in the first year. In other cases the benefits obtained by inoculation have not been sustained after the first year, and plant yields with inoculated seed have ultimately declined below uninoculated controls. Here it is believed that the inoculated rhizobia have been unable to oversummer the hot dry period in the absence of the host plant.

(*c*) *Fractionation of Soil Humus.*—Attempts have been made to fractionate humic acid into its component colloidal constituents by fractional precipitation, partition and adsorption chromatography, and paper electrophoresis, but without success. All constituents move as a single entity, suggesting strong bonding between them, so methods are being devised for severing some of these links, after which further attempts will be made to fractionate the acid.

III. PLANTS.

1. GENERAL.

In view of the importance of primary industries i the Australian economy the Organization has place considerable emphasis on investigations of plant problems. Work in this field is undertaken mainly by th Division of Plant Industry which has head-quarters i Canberra and experimental farms and stations at number of centres throughout the Commonwealth. Th work of the Division of Plant Industry is described i this Chapter. Sections 11 and 19 describe the work c the Division of Biochemistry and General Nutrition o mineral nutrition of plants.

Work on special local problems of irrigation district is undertaken at the Commonwealth Research Statio (Murray Irrigation Areas) at Merbein, Victoria, an the Irrigation Research Station (Murrumbidgee Irrigation Areas) at Griffith, New South Wales (*see* Chapte IV.).

The Division of Entomology is carrying out wor on weed control, insect pests of pastures and crops, an insect vectors of virus diseases (*see* Chapter IX.).

The Land Research and Regional Survey Section carrying out broad-scale ecological surveys in the unde developed arid and semi-arid regions of the continen to assess their land-use potential and investigate problems of agricultural and pastoral development. Th work on the regional surveys is reported in Chapte XI., Section 2, and the Section's investigations o crops, fertilizers, plant diseases, tillage, and native an introduced pastures under dry land cultivation at th Katherine Research Station, and under irrigation the Kimberley Research Station, are reported Chapter XI., Section 3 *et seq.*

Division of Plant Industry.—The work of the Div sion is mainly directed to long-range or fundament research beyond the resources of the State Departmen of Agriculture. Particular attention is given to problems having a Commonwealth-wide rather than Sta importance.

Much of the research of the Division is conducted regional and field stations in many parts of the Con monwealth, with emphasis upon the problems of th pastoral industry, the fruit industry, and special cro such as tobacco and oil plants. Work is conducted the head-quarters and main laboratories at Canberr and Dickson Experiment Station, Australian Capit Territory (which also acts as a regional field statio and at the following centres:—Institute of Agricultur Nedlands, Western Australia (pasture studies and pla introduction); Glen Lossie Field Station, Kojonu Western Australia (pasture studies); Kelmscott Intr duction Station, Western Australia (plant introdu tion); Waite Agricultural Research Institute, Adelaid South Australia (oil crops); Regional Laborator Hobart, Tasmania (apple investigations); Falkin Memorial Field Station and Regional Pastor Laboratory, Deniliquin, New South Wales (pastu studies); Regional Pastoral Laboratory, Armida New South Wales (pasture studies and plant intr duction); Mitchell Laboratory, Trangie, New Sou Wales (pasture studies, with New South Wales Depa ment of Agriculture); Plant and Soils Laborator Brisbane, Queensland, and Strathpine Experime Station (pasture studies, plant introduction); Coop Laboratory, Lawes, Queensland (pasture studies); A Queensland (tobacco, with Queensland Department Agriculture); Katherine Experiment Statio Katherine, Northern Territory (plant introduction a tobacco). In addition, extensive trials are conduct on leased or private properties in districts outside t regional centres. Many of the research projects a carried out in conjunction with the State Departmen of Agriculture and the Universities.

During the year considerable attention was given to the re-organization of the activities of the Division. Increased emphasis has been given to fundamental studies and the work on plant chemistry, biochemistry, physiology, microbiology, genetics, and cytology will be extended. Three Senior Research Fellows have been appointed. To accommodate these increased activities there has been erected at the head-quarters of the Division a number of new buildings and glasshouses.

Dr. J. Griffith Davies, Associate Chief of the Division, was transferred to Brisbane to take charge of expanded research on agricultural problems of Queensland. The Queensland Pasture Liaison Committee was established with the purpose of assisting in the interchange of information on pasture research in Queensland and to co-ordinate the activities of the Queensland Department of Agriculture and Stock, the Division of Plant Industry, and the University of Queensland.

Also during the year that portion of the plant physiology work formerly located at the Waite Agricultural Research Institute was transferred to Canberra. New laboratories were designed and equipped, including three growth rooms for plant hormone assay investigations. In conjunction with the Central Experimental Workshops a prototype controlled environment room has been installed and tested. Information from this model will be incorporated in further rooms. These will provide excellent facilities for a wider range of investigations for which close control of the major environmental factors — temperature, light, and humidity—is necessary.

Officers of the Division co-operated in a " Conference Tour " for research and extension officers concerned with pasture development in the Southern Tablelands region of New South Wales. The object of the tour was to discuss the practical application of research results indicating that the carrying capacity of the region could be increased at least threefold by correcting soil deficiencies. A similar tour is being arranged for the Northern Tablelands region.

In conjunction with the Victorian Department of Agriculture, the Division co-operated in organizing a Commonwealth conference of tobacco technical officers at Myrtleford, Victoria. A Plant Introduction Conference was held in Canberra and was attended by representatives of Universities, Commonwealth Government Departments, and the Organization.

Dr. J. Griffith Davies led the Australian delegation to the sixth International Grasslands Congress held at Pennsylvania, United States of America. Dr. Davies was also a member of the combined team of United Nations Food and Agriculture Organization experts which was formed at the request of the Government of Pakistan to advise on the development of Baluchistan. The Division has representatives on numerous coordinating and joint committees comprising representatives of Commonwealth and State Government Departments, Universities, farmers' organizations, and other Divisions. An officer of the Division is the official Australian member on the International Seed Testing Association.

2. PLANT INTRODUCTION.

(Division of Plant Industry.)

(*a*) *Introduction and Exchange of Plants and Seeds.*—There was a decrease in the number of seed samples received from abroad during the year, largely because there were no officers collecting overseas. Nevertheless, over 1,300 samples were received, mostly from research workers in the Mediterranean countries and Africa with whom personal contact was established in the previous year by the plant exploration team. Besides the usual close quarantine examination to which all samples are subjected, additional precautions were taken against the introduction of new virus diseases by growing all legumes introduced under controlled conditions and examining for the presence of virus. Over 900 samples of seed of Australian plants were sent in exchange to overseas institutions mainly in the United States of America, Portugal, India, Kenya, and the United Kingdom. About 900 introductions were distributed to institutions in Australia, particularly to the State Departments of Agriculture and New Guinea.

(*b*) *Plant Geography.*—Although officers were not collecting overseas during the year, plant exploration has had a dominating influence on the work of the plant introduction unit. Many varieties which had been collected in the Mediterranean region and in Africa were grown for the first time in quarantine nurseries at Canberra, Brisbane, Perth, and Katherine. In addition, certain groups were studied more intensively at Canberra and Perth. Populations of many strains of the grass genera *Phalaris, Dactylis, Lolium, Hordeum,* and *Oryzopsis,* and of the legumes *Trifolium* and *Medicago* were compared *inter se* and also with standard Australian varieties. Detailed morphological and phenological observations were made as a basis for assessment of intervarietal and intravarietal differences. It is hoped that careful study of these differences will throw light upon the origin of the Australian varieties and their evolutionary development since establishment here. Comparison of the performance of the strains in Australia with the climatic and other environmental conditions of their place of collection will assist in the critical evaluation of comparative climatology as a plant introduction technique. From the first season's trials, the value of the collections is already evident. They include numerous types differing greatly in maturity and other physiological characters. Many are earlier than any of the existing Australian varieties, and hence many prove valuable in marginal areas where the season is too short for the full development of the commercial strains. Earliness in maturity was found to be associated with origin, especially at Perth where there was a range from extreme earliness, represented in strains from Cyprus, to lateness in strains from the northern Mediterranean countries and from Morocco.

Trials are being established at several marginal centres in New South Wales, South Australia, and Western Australia where the survival of the strains under adverse conditions will be tested and their agronomic value determined. At Canberra, Perth, and Armidale quantitative growth studies were initiated and seed supplies are being built up from isolation plots at Canberra. A new vegetation map of Australia was completed and will be published as part of an atlas of Australian resources. A paper has also been completed dealing with the distribution of grasses throughout the world and the significance of this distribution for plant introduction studies. A survey of regions for future plant exploration has highlighted the importance of southern Mexico and Guatemala as a source area for tropical pasture legumes, especially species of the genera *Desmodium* and *Phaseolus.*

(*c*) *Agronomic Trials.*—(i) *South-eastern Australia.*—During the year, a technical officer was transferred to Armidale to take charge of plant introduction work in this region. This is in recognition of the increasing importance of pasture investigations in northern New South Wales and the promising results obtained in introduction trials. At Armidale some of the introduced varieties of tall fescue have continued to be outstanding, while strains of chickpea from Spain and Eritrea appear to be useful, drought-resistant, quick-growing forage plants. Further north, at Crooble on the north-western slopes, perennial summer-growing grasses from South America and South Africa are outstanding. *Sorghum almum* is being sown on a large scale for grazing and seed production, while the Bambatsi strain of *Panicum coloratum* and the fine-leaved Katambora strain of Rhodes grass, both from Southern Rhodesia, are being developed as rapidly as possible. The trials in this region are being conducted in close co-operation with officers of the New South Wales Department of Agriculture, while liaison is also maintained with the Soil Conservation Service in trials at several centres throughout the State.

Agronomic work on *Lathyrus ochrus* and on canaigre (*Rumex hymenosepalus*) has been completed. It was shown that the former is a useful green manure and cover plant for light soils in the irrigation areas. Canaigre, which is being tested as a tannin plant, has yielded well on light soils at Mildura and in Western Australia, but is unthrifty on heavier soils. Tannin analyses are in progress and will complete the assessment of its economic potentialities.

(ii) *Queensland.*—Nearly 700 new introductions were established in the quarantine nursery at Strathpine, comprising principally large collections of pasture and crop plants from Africa. The grasses have been tested for hydrocyanic acid content and the legumes for alkaloids. Positive hydrocyanic acid reactions were recorded for some introductions of *Andropogon, Chloris, Cynodon, Hyparrhenia, Leptochloa, Pennisetum,* and *Sorghum,* and positive tests for alkaloids in *Cassia, Dolichos, Desmodium, Dichilus, Indigofera, Lupinus, Pennisetum, Setaria, Sorghum, Thelopogon,* and *Urochloa.* Preliminary evaluation of this material will commence next season using methods of chemical appraisement and growth and development comparisons with outstanding introductions to be selected for bulk seed production. Later, environmental testing is planned for those pasture species exhibiting high levels of nutritional quality and vigour.

The more promising pasture plants previously introduced from South America and elsewhere were established in seed production rows at Strathpine. Regional testing of these introductions has been continued at Maryborough, Kuraby, Lismore, and Cecil Plains. The tests include a study of the defoliation reactions, yield, and chemical composition of plants grown at different fertility levels. This permits the sorting of introductions into two groups—one showing pronounced response to fertilizer which might be suppressed by inadequate water status, and the other revealing an uneconomic return under equivalent conditions. Among the grasses tested, *Paspalum simplex* is characteristic of the first group, and *P. notatum* of the second. *P. notatum* has an excellent nutritive balance and is sufficiently aggressive to compete with, and probably replace, some inferior natural pasture species. *P. simplex* also has aggressive habits, but, unlike *P. notatum,* its nutritive value falls off rapidly approaching maturity. Of the legumes, *Stylosanthes* does not respond well to fertilizers but undoubtedly has a place in the improvement of large areas of natural pastures. A strain of *Desmodium uncinatum* and one of *Aeschynomene falcata* have performed well and will receive further attention.

(iii) *Northern Territory.*—The preliminary phase of introduced crop plant testing at Katherine, which has been in progress since 1947, has been almost completed. It has covered the examination of many varieties of oil plants, fibre plants, green manures, cover crops, and pulse crops to assess their adaptability to the climatic conditions and their potential economic value. Among the oil crops, sesame, rapeseed, sunflower, and peanuts have proved to be well adapted, and the best varieties have been released for more extensive testing under field conditions. Fibre plants, other than cotton, have shown little promise, though some varieties of roselle have given fair returns. Cowpeas, lablab, and velvet beans are the best of the green manures, but only cowpeas are sufficiently early maturing for Katherine conditions without supplementary irrigation. Some introductions of *Phaseolus* are outstanding as pulse crops, with high yields of protein-rich grain. There is sufficient evidence to warrant the belief that this genus will ultimately provide extremely important agronomic material for pulse cropping over a range of climatic and edaphic conditions in northern Australia.

More than 200 species of pasture grasses have been tested, and a small group of species representing important African grasses has been studied more intensively, both agronomically and chemically, over three seasons. Compared with six native species from the Kimberleys previously tested by the Western Australian Department of Agriculture, the African introductions have less crude fibre and more protein. Even so, they have a very low nutritive value during the dry season, and it is considered that reliance will have to be placed on legumes to maintain nutritive values during this period. None of the legumes so far tested is wholly satisfactory under Katherine conditions, though *Stylosanthes bojeri* from Tanganyika, and *Teramnus labialis* from Malaya are promising. It is expected that the recent African exploration will provide better basic material for research in this field.

(iv) *Western Australia.*—About 430 new introductions have been grown at Kelmscott, including 130 which were studied in considerable detail as indicated in the discussion of plant exploration. Of the other introductions, the legumes proved to be interesting botanically but generally disappointing agronomically, as most of them make poor growth during the autumn and winter and were too late maturing. The grasses promise to be of more value, the best being annual species of *Bromus* and *Phalaris.*

A critical comparative study is being made of many strains and species of *Ehrharta* which were collected in the Cape Province of South Africa. These include rhizomatous forms which may be better able to withstand heavy grazing than the perennial veldt grass which is widely naturalized in Western Australia.

Replicated trials of crop and pasture plants at Perth and Kojonup have generally confirmed the results of previous years. Close co-operation has been maintained with the Western Australian Department of Agriculture in the regional testing of more promising varieties, and many samples have been supplied for new co-operative trials at Carnarvon.

(*d*) *Systematic and Economic Botany.*—The activities of the herbarium were on a reduced scale during the year because of the absence abroad of the systematic botanist, who has been seconded to the Kew Herbarium for two years as Australian liaison officer. Several important collections were received, including notably plants from Arnheim Land donated by Mr. L. Specht, New Guinea plants donated by Mr. J. S. Womersley, and Queensland specimens collected in the course of an alkaloid plant survey by Mr. L. J. Webb. Many of these have been mounted and laid in the herbarium, which now includes 27,877 specimens.

3. PLANT GENETICS.

(Division of Plant Industry.)

(*a*) *Inheritance of Hard Seededness, Earliness, and Mosaic Resistance in* Trifolium subterraneum.—The extension of subterranean clover into northern coastal regions of New South Wales is dependent on selecting varieties that produce a relatively high proportion of hard seed which does not germinate with the summer rains. Seedlings developed in the summer usually die off before the normal growing period in the winter. Hard seededness depends on environmental and genetical factors, some varieties like Dwalganup and Northam

First Early consistently producing a high percentage of hard seed. Second generation progenies from crosses between these varieties gave significantly greater proportions of hard seed than crosses such as Tallarook x Mount Barker.

Tallarook has tended to become the standard variety in the coastal areas of New South Wales, but it often makes the bulk of its growth and sets its seed too late in the season. By crossing this variety with early ones, as Dwalganup and Northam First Early, F_2 segregates with vigorous growth and seed-setting earlier in the season have been produced. At the same time the inheritance of time of flowering and hard seededness are being studied. It appears that there may be a relation between earliness and hard seededness.

A legume virus in the Bean Mosaic II group, although not causing severe damage in subterranean clover, was widespread in this species during the 1952-53 season at the Dickson Experiment Station, Canberra. It occurs sporadically in other areas in Australia and is carried by aphids. Varieties like Dwalganup, Northam First Early, and Pink-flowered, with a lethal reaction to this virus in the glasshouse, apparently possess a degree of field resistance. The inheritance of the lethal reaction to this legume virus is being studied in the F_2 progenies of appropriate crosses.

(*b*) *Relation Between Autotetraploidy and Virus Reaction in* Trifolium subterraneum *and* Physalis floridana.—It has been shown that doubling the chromosomes of a species does not always affect its reaction to viruses. In subterranean clover, the reaction to legume mosaic in a number of varieties is greatly increased in severity by doubling their chromosomes. Of the viruses which infect *P. floridana*, only the leaf-roll virus gives a markedly severe reaction with the autotetraploid of this species.

(*c*) *Interspecific Hybridization in the Genus Phalaris.*—Two sterile interspecific hybrids have been produced from the use of the annual *P. minor* as male parent, and the perennial *P. tuberosa* and *P. caerulescens* as the female parents. By doubling the chromosomes of the two hybrids with colchicine, fertile perennial, allopolyploid species *P. tuberosa–P. minor* with 56 chromosomes, and *P. caerulescens–P. minor* with 42 chromosomes have been produced. *P. minor* has some ability to grow during cold weather, and is also common as a weed in the wheat belt, so it is hoped that the new allopolyploids will be adapted to the wheat belt and also to the Southern Tablelands of New South Wales.

(*d*) *Effect of Autopolyploidy in Pasture Species.*—In subterranean clover, the autopolyploids of a number of varieties are normal in appearance, and all are more vigorous than the diploids during the first four to six weeks of growth. In the Dwalganup variety, increased dry matter production was maintained throughout the season by the tetraploid, but in the other varieties the diploids exceeded the tetraploids by the end of the season. Although seed production was reduced in the tetraploids, it was not serious enough to prevent their use.

From the cross-pollinated white clover (*Trifolium repens*) a number of promising autoploid lines has been developed, and these appear to possess a greater ability to stand up to hard conditions, such as dryness, than the diploids. Some of the lines are more vigorous than the diploid, have good seed yields, and low cyanogenetic activity.

Autoploid *Medicago tribuloides* lines have promise and are being tested further. Other species of *Medicago,* including lucerne, did not respond favorably to polyploidy.

(*e*) *Combination of Spotted-wilt Resistance, Fusarium-wilt Resistance, Eelworm Resistance, and Desirable Agronomic Characters in the Tomato* (Lycopersicon esculentum).—The variety Rey de los Tempranos possesses a heritable resistance to spotted wilt, and techniques for incorporating this resistance into commercial-type hybrids with resistances to fusarium wilt and nematode have been developed. The resistance of Rey de los Tempranos is expressed by an ability to produce healthy shoots if infected. This physiological form of resistance is apparently recessive, and a low percentage of phenotypes possessing it is recovered in progenies.

In conjunction with the Commonwealth Research Station, Merbein, the project to develop commercially acceptable hybrids with nematode and fusarium wilt resistances has been taken a step further. Six promising hybrids have been selected from the progenies, three with determinate and three with indeterminate habit. The segregations for nematode resistance have not been clearly defined but indicate that the character is recessive.

(*f*) *Combination of Virus Resistance, Late Blight Resistance, and Desirable Agronomic Characters in the Potato* (Solanum tuberosum).—Leaf-roll resistance, as possessed by the Bismark variety and certain hybrids, appears to depend on a virus-inactivating system which keeps the virus concentration at a low level in infected leaves. This results in plants producing normally, and in a very low transmission of virus to the tubers. Where varieties or hybrids with this character become infected severely, leaf-roll transmission to the tubers is again restricted so that a proportion of them produces healthy plants.

Further crosses have been made to incorporate this leaf-roll resistance character with resistances to viruses X and Y, and to the fungus late blight.

4. STRUCTURAL BOTANY.

(Division of Plant Industry.)

(*a*) *Development of Spikelets in Basal Sterile Speltoid Wheats.*—Progress has been made in the study of the morphological and histological development of the spike in the basal sterile speltoids St_1 and St_2 and for comparative purposes in the *vulgare* varieties Yeoman and Victor. Prior to the differentiation of the first flower, primordium development is substantially the same in all types. Only in failure to differentiate basal flowers do St_1 and St_2 differ from the normally fertile types.

The tissues of the vegetative apex are clearly defined in three zones, namely:—(1) a single outer layer of cells (dermatogen) which divide only by anticlinal walls except where a leaf primordium is initiated; (2) a second single layer of cells (hypodermis) which also divide only by anticlinal walls except where a leaf primordium is formed; and (3) a central core of cells within these two shells. The cells of the core divide by walls in various directions and are derived from a small group of cells at its apex. Leaves arise by divisions of the dermatogen and hypodermis whilst axillary buds are initiated by periclinal divisions in a plate of cells in the outer layers of the core. The spikelet primordia and the flower primordia arise histologically as axillary buds, the empty glumes and lemmas as foliar structures.

During the period of differentiation of the spike, leaf initials are formed in rapid succession but progressively fail to develop. When the "inhibition" to leaf primordium growth reaches a certain stage the differentiation of axillary bud initials commences. Following a short transition period the growth of the foliar primordia is almost completely inhibited and the growth of the bud initials (spikelet primordia) becomes dominant.

In most of the spikelets of St_2 except the four or five nearest the top of the spike no flower is formed in the axil of the first or second lemmas. In the more distal spikelets the second lemma may subtend a flower or an imperfect flower or be completely sterile. In the remainder of the spikelets there is rarely any indication of the formation of any axillary initial at all. In St_1 flower formation in the axil of the first lemma is comparable with that of the second lemma in St_2. The sterility of the basal lemmas is therefore derived from either initial failure to differentiate flower primordia or the failure of the flower primordia to grow at any stage during their development. There is a definite trend to greater fertility in basal flowers from the centre to the tip of the spike.

5. MICROBIOLOGY.

(Division of Plant Industry.)

(*a*) *Virus Investigations.*—(i) *Reconstitution of X-infected Potato Varieties by Chemotherapy.*—Successful results were obtained by the use of the diaminotriphenylmethane dye Malachite Green. The potato variety under test, Early Carman, was grown as a bacteriologically sterile clone in complete nutrient. Small stem tips were floated in nutrient containing the Malachite Green so that they were completely exposed to its action for three weeks. The growing tips were then transferred again to nutrient without dye and when sufficient growth had occurred were tested for presence of virus X. One tip was free from X. It has now been clonally propagated and virus-free tubers will shortly be available for distribution. The technique is so simple that it should be possible to derive other virus-free varieties in a similar manner.

(ii) *Assessment of Virus Chemo-therapeutants.*—Recent work elsewhere has indicated that viruses might be controlled by chemical means. The growing of plants aseptically in culture solution appeared to offer a technique whereby they might be intimately exposed to test chemicals under controlled conditions. A co-operative project was arranged with Taubmans Ltd., who supplied a range of chemicals for testing. Testing was begun using potato infected with virus X, growing in a complete nutrient to which the test chemical was added. So far only a few compounds have been tested.

(iii) *Host Range Studies of Lucerne Witches' Broom.*—Transmission studies by grafting and dodder (*Cuscuta campestris*) were terminated after some study of the symptoms produced on potato. The identity of witches' broom with tomato big bud was confirmed as much as it ever can be with a virus of this type. The great similarity of the Australian big bud virus to the American aster yellows virus also became very apparent in these studies. The investigations on witches' broom have been completed and written up as a series of three papers for publication.

(*b*) *Antibiotic Investigations.*—(i) In Vitro *Tests of Commercial Antibiotics against Bacterial Pathogens of French Bean, Tomato, and Crucifers.*—Comparative *in vitro* tests have shown that streptomycin and aureomycin are more effective than bacitracin, chloromycetin, terramycin, and penicillin in inhibiting growth of *Corynebacterium michiganense, Xanthomonas vesicatorium, X. phaseoli, X. campestris, Pseudomonas medicaginis,* and *P. syringae.* Total inhibition at concentrations as low as 0.25 p.p.m. has been obtained.

(ii) In Vivo *Studies of Streptomycin against Bacterial Canker* (Corynebacterium michiganense) *of Tomato.*—Preliminary absorption studies showed that streptomycin was readily absorbed into the plant via the roots. It is remarkably stable in leaf tissue, being easily demonstrable by bioassay 63 days after cessation of treatment. It appears to become "fixed" in the tissue and is not transferred to young growing leaves. Marked phytotoxicity is evident at concentrations greater than 4 p.p.m.

Treatment with 10 p.p.m. streptomycin for seven days, commencing within 72 hours of innoculation, prevents wilting of tomato by the pathogen but the organism is not killed and may be consistently re-isolated from the plant.

(iii) *Comparison of the Antibiotic* Cycloheximide *(Actidione) with "P.A.C.A." against Dollar Spot of Turf.*—"P.A.C.A." (phenylamino cadmium acetate) is an established turf fungicide. The opportunity offered by a severe outbreak of dollar spot in the summer of 1953 was taken to test the value of the antibiotic which is acclaimed as a good turf fungicide in the United States of America. Both treatments gave some control, but response was too slight to allow valid conclusions.

(*c*) *Rhizobium Strain Isolation and Testing.*—Attempts to establish improved pastures in some areas of New South Wales (Wagga, Temora, Badgery's Creek, Camden Park) have failed owing to the disappearance of the sown legume after the first season. One suggested cause of failure was ineffective nodulation. In co-operation with the Agrostology Section, strains of *Rhizobium* have been isolated from many hosts in these areas and tested for effectiveness *in vitro.* Many strains isolated from medics and clovers have been shown to be ineffective.

Sub-tropical legumes under study in Queensland by the Plant Introduction Section have in many instances shown symptoms of nitrogen deficiency and ineffective nodulation. Where possible, isolates of *Rhizobium* have been obtained from odd plants that have been successfully nodulated naturally, and these are being tested for effectiveness *in vitro.*

(*d*) *Pasture Diseases in the Ninety-Mile Plain, South Australia.*—This co-operative project with the Division of Biochemistry and General Nutrition was completed after late season observations were made on the infection trial at Keith. Two types of bare patch, one caused by *Rhizoctonia solani* and one by nematodes, are easily recognizable and distinct. A third disease, "General Unthriftiness", is still obscure. *Corticium praticola* is definitely involved as a pathogen but its attack on the pasture appears to be conditioned by some nutritional condition not as yet understood.

(*e*) *Pine Tree Nutrition Experiments.*—These long-term trials at Penrose and Woodburn have several years to run. Final measurements were made on plots of older trees at each of the sites in July, 1952, but plots of younger trees remain. All results point to a striking response of pines to phosphate on these poor podsoil soils, but it will be necessary for all trials to run to completion before the economics of phosphate application can be properly assessed.

(*f*) *Microbiological Population of Soils in Relation to Fertility Build-up.*—Members of the agrostology group are interested in the increment of soil fertility under subterranean clover pasture and superphosphate dressing. Since microflora of the soil are intimately associated with structural and chemical changes that occur, it is important to have some idea what is happening to the soil flora under this régime of subterranean clover and superphosphate. A start has been made to establish standards of comparison by determining, for each of the important groups of the soil microflora, the numbers which can normally be expected to be present in known fertile soils at different seasons of the year. Opportunity is being taken to check the microbiological status of variously treated soils in agrostological pot experiments at Canberra.

(*g*) *The Mechanism of Ion Reduction by Bacteria.*—This project was begun at Rothamsted and was completed at the University of Melbourne. It was shown that the reduction of ferric compounds by bacteria occurs as a result of reducing conditions produced by dehydrogenase systems. It is suggested that this type of reduction may be important in supplying plant nutrients from iron and manganese oxides.

(*h*) *Effect of Microbial Activity on Phosphate Availability in Soil.*—Since phosphate availability in soil is of such great importance in pasture development, investigations have been commenced to determine whether micro-organisms play any significant part in the story.

(*i*) *Seedling Blight.*—A technique was devised for determining the population density of infective particles of *Pythium* in soil. Applying this technique to the soil of the Dickson Experiment Station revealed that most of the *Pythium* particles were intimately associated with the colloidal coating of the sand grains and that the number of sand and other particles so infested was of the order of 1000/g.

(*j*) *Take-all of Wheat.*—In a rotation experiment made in drums, there was an interaction of rotation and artificial infestation of the soil with a culture of the pathogen. Two years oats, two years Wimmera rye, and two years peas were each followed by higher yields of wheat than were obtained in any of six other rotations.

In a parallel experiment, in which five of the elements of plant food were added to the soil in each of four years, there was no interaction of plant food and artificial infestation of soil.

6. Fruit Investigations.

(Division of Plant Industry.)

(*a*) *At Hobart.*—(i) *Physiology of Fruit in Relation to Storage Disorders.—Comparison of varieties:* The studies of light and heavy crop fruit of different varieties which gave valuable results in 1950-51 were continued, using, where possible, the same pairs of trees. The results were confirmatory; the change in cropping level from one year to the next did not affect the relationships between light and heavy crops.

Progress of maturation: The progress of fruit development was continued in trees of light and heavy crop of two early maturing and two late maturing varieties of low and high disorder susceptibility.

Breakdown susceptibility in relation to respiration during storage: The study of the progress of respiration and change of protein content during storage in relation to the development of breakdown was commenced. An increase in protein nitrogen content was detected at the time of onset of breakdown.

The effect of manurial treatment on keeping quality and its relation to cell size and physiology: Following evidence obtained last season that keeping quality appeared to be related to cell size and respiration per unit protein, plots were selected to study the effect on these variables in a range of cropping levels within a variety, and the effect of varying the nitrogen level alone and in combination with potassium and phosphorus.

The elements were applied as sprays either just after petal fall during the period of fruit cell division or in January during the period of fruit cell enlargement. The effect of adding the growth substances 2,4-D and A.N.A. in the early sprays was also studied.

Although this was the first season of treatment and residual effects from the former commercial manuring reduced the effect of the spray applications the following results are indicated:—

(1) There was no response in the fruit to the mineral elements of the early spray but there was a small response to growth substances. Satisfactory quantitative response to the later applications occurred and the method provides the means of inducing quick changes in mineral content.

(2) There was a strong intercorrelation between the following variables:—Percentage disorder, mean fruit size, cell volume, and respiration per unit protein, thus supporting the theory developed from the earlier survey of varieties that variation between trees in incidence of respiratory disorder may be due to difficulties in protein maintenance.

(3) Respiration per cell, protein nitrogen per cell, cell volume, and respiration per unit protein were intercorrelated, which supports the theories of fruit respiration developed by officers of the Division of Food Preservation.

(4) No significant modifying effect of phosphorus and potassium on the action of nitrogen could be shown though there were indications that the addition of phosphorus might reduce the R/P ratio and the incidence of disorder. January treatment with nitrogen alone or in combination with potassium and phosphorus increased the R/P ratio and disorder above that of the controls.

(5) The data showed an interaction between the disorder Jonathan spot and breakdown, each tending to suppress the other. This relationship had not been demonstrated previously.

(6) A correlation between the incidence of rots developing in storage and the mean fruit size and other intercorrelated variables indicated a relation between fruit physiology and fungal development.

(ii) *Gas Storage Trial.*—From the results obtained in 1950-51 and 1951-52 it appeared that the conventional gas mixtures containing carbon dioxide increased the susceptibility of Tasmanian varieties to scald and breakdown to a dangerous extent. The use of higher temperatures to counter this reduced the value of the method below economic levels.

From physiological considerations and the results of a small experiment in an earlier investigation, it was considered desirable to test the value of storage in low concentrations of oxygen in the absence of carbon dioxide.

Preliminary trials with the varieties Golden Delicious, Delicious, Granny Smith and Sturmer at 5 per cent. oxygen, 0 per cent. carbon dioxide at 32, 34 and 36° F. have shown that the method is very promising; scald and breakdown are reduced even at low temperature and texture greatly improved. The method is, however, inferior in control of colour change.

(*b*) *At Applethorpe.*—(i) *Rootstock Trials.*—An attempt is being made to determine the relation between the time of blossoming and the cell number and cell size in Granny Smith fruits at maturity. Bain and Robertson have shown that, when cell division is completed at about 21 days after pollination, there is a wide range in cell numbers in young Granny Smith fruits. As the period of blossoming is of the order of ten days, it is possible that early and late pollinated flowers may differ in their rates of cell multiplication.

Using fruit from the 1951-52 crop, it was found that the mean cell number for Granny Smith fruits is similar to that found by Martin and Lewis in Tasmania, for apples from their source 1. The mean cell numbers for the fruits from the rootstocks studied are: Northern Spy, 335 x 10^5; Seedling, 331 x 10^5; M XII, 327 x 10^5; M XVI, 312 x 10^5. There is no apparent influence of rootstock on the mean cell number of fruits of Granny Smith.

The mean cell volume is largest for fruits from trees on Northern Spy stocks, which bore the largest fruits; and lowest for fruits from trees on M XII stock, which bore the fruits of lowest mean weight.

From starch-iodine tests made with Granny Smith fruits from trees on different rootstocks, it appears that fruits from Seedling and Northern Spy stocks are more matured at a specified picking date than the fruits from trees on M XII and M XVI stocks.

In the older established rootstock trials, the relative order for vigour of growth and for cropping remains unchanged. The stock trial with Delicious on the four Merton stocks, Essfour, Spy, and own-roots shows, by girth measurement, that already at two years the trees on Essfour have made the greatest growth and the trees on Spy the least.

(ii) *Tree Replacement Investigation.* — *Arsenic accumulation in old apple orchards as a factor in tree replacement:* This investigation involved the determination of the arsenic concentration of orchard soils in which it had accumulated as a result of regular spraying with arsenicals over a long period. It was concluded that, at the present levels, accumulated arsenic in old orchard soils is not responsible for the poor growth frequently made by replant trees.

Root lesion nematodes and tree replacement: The first report on this investigation is in the press. The report embraces: (1) A study of the effect of *Pratylenchus coffeae* on the growth of quince, peach, plum, pear, apricot, walnut and grape. (2) A field trial to compare the growth of apple trees on the following rootstocks in nematode-infested soil: Mertons 778, 789, 793, and Northern Spy. (3) A study of population changes of *P. coffeae* under conditions of moist fallow. Under these conditions, soil was free of nemas in 8-9 months. (4) The evaluation of the following methods of control in glasshouse pot experiments with apple seedlings: fumigation with "D.D.", soil treatments with different levels of sodium selenate and 66 per cent. bisdimethylaminophosphonous anhydride, air-drying infested soil for four months prior to planting. Soil fumigation was the most satisfactory treatment. Air-drying gave some measure of control.

(*c*) *General.*—(i) Thielaviopsis basicola *on* Lupinus angustifolius.—A disease of New Zealand blue lupins at the Field Station, Applethorpe, was found to be caused by the fungus *T. basicola.* This is the first record of the disease in Queensland.

(ii) *Collection and Identification of some Australian Nematodes.*—A large number of nematodes has been collected and identified. Work in this field is now restricted to plant parasites and suspected parasites.

7. OIL CROP INVESTIGATIONS.

(Division of Plant Industry.)

(*a*) *Safflower* (Carthamus tinctorius).—The semi-drying oil from this plant is used as a linseed oil substitute and is especially valued for its non-yellowing properties and its suitability for alkyd resin preparations.

(i) *Variability and Inheritance Studies.*—Extensive studies on safflower introductions have shown a wide range of variability of agronomically important characters offering excellent conditions for a selective breeding. After the breeding system of the crop and its artificial cross pollination technique were determined, a series of intervarietal crosses were carried out for studies on the mode of inheritance of some characters and their utilization in improvement of the material.

(ii) *Selection and Yield Trials.*—As a result of selection studies a number of improved lines have been developed. These have been submitted to extensive trials, under various conditions of growth, to determine their earliness of emergence, early growth and maturity their yielding ability and oil content, and degree of spininess and rust resistance. In addition to a wide range of safflower adaptability, these trials have indicated a great yielding capacity of some strains under favorable conditions, comparable with thê best in other countries. Also an increase in oil content from 28 to about 40 per cent. was found in some strains.

(iii) *Economy of Safflower Growing.*—Regional trials were set up in conjunction with various State Departments of Agriculture to determine the relative acre yield value of safflower and linseed as compared with wheat. From the results so far obtained, it appears that, under favorable conditions, the yield and monetary value of safflower per acre exceeded that of linseed. The monetary returns per acre of safflower compared more favorably with wheat than linseed.

(iv) *Edible Oils.*—A safflower line was found which owing to its oil quality, has great promise as an edible oil. A hybridization programme is under way to improve on some agronomic properties of this type.

(*b*) *Linseed.*—This crop, which is already grown commercially, needs some improvement of its yielding properties, oil content and oil quality, and resistance to diseases (rust and pasmo). Yield trials have been set up to determine the performance of our hybrid lines originating from a cross of Walsh x Punjab. Some of these lines exceed the commercially grown variety Walsh in yield and oil quality, and combine the rust resistance of both parents. Studies on the degree of cross pollination in linseed and on the effect of harvesting at different stages on the yield and quality of the seed had been completed.

(*c*) *Castor Beans.*—Introductions of this important oil crop are being investigated, particularly as to their usefulness in commercial production.

8. TOBACCO.

(Division of Plant Industry.)

(*a*) *Leaf Quality.*—The investigation on the effect of nitrogen and plant spacing on leaf quality was continued at Clare on the Tobacco Experiment Station of the Queensland Department of Agriculture and Stock Nitrogen was applied at rates of 16, 24, 32 and 40 lb./acre and plants were spaced at 15, 20, 30 and 35 inches in rows 4 feet apart. The general trend of the results was similar to that obtained in the previous season.

Highest yield of good quality leaf was obtained with lowest nitrogen and differences between 24, 32 and 40 lb nitrogen were not significant. There was a trend toward highest yield at the 20-in. spacing. The quantity of leaf that cured green was greatest at 15-in. spacing and was independent of nitrogen supply. Although the quantity and quality per acre were reduced by the wider spacings, the yield per plant was increased, so that it may be economical to reduce plant number per unit area.

(*b*) *Varieties and Disease Resistance.*—Thirteen hybrids containing the genetic factor for the necrotic type of resistance to tobacco mosaic were grown at Clare. Those possessing the required agronomic characters were selfed and the progeny is now under test for retention of dominant factors for resistance.

The effect of temperature on the resistance of tobacco plants carrying the necrotic type of resistance to tobacco mosaic is being investigated at Canberra. At temperatures above 75° F., inoculated plants are severely affected and usually killed by vascular necrosis. With temperatures of the order of 100° F. typical mosaic mottle occurs.

One of the varieties grown at Clare was not attacked by the looper caterpillar (*Plusia* spp.), a major pest in the district. Crosses were made to determine whether or not this character is inherited.

A good response has been obtained to an Australia-wide appeal for seeds of native *Nicotiana* species. The material received is to be tested for disease resistance and examined for other characteristics likely to be of value.

(*c*) *Diseases and Disorders.*—An increase in the number of plants available for studies on the yellow dwarf virus disease was obtained by vegetative propagation but the presence of the virus reduced the number of cuttings that rooted by 50 per cent. Cuttings from "frenched" plants were affected similarly. The number of cuttings that rooted was not increased by treatment with indolebutyric acid. Further attempts to transmit yellow dwarf mechanically or by dodder were not successful. A histological examination of yellow dwarf plants failed to reveal abnormalities due to the presence of the virus.

Frenching, a disorder of unknown cause, was widespread in four acres of tobacco at the Katherine Research Station, Northern Territory, and affected yield and quality to a marked extent. It also occurs in the Manjimup area of Western Australia and has been observed in north Queensland. A few lightly affected plants occurred at Katherine in earlier years but there was nothing to indicate that frenching could become of major importance. Although frenching is one of the earliest tobacco troubles to be described and is common in other countries, methods of control are unknown. Investigations on the relation of nutrition, soil, water supply, &c., to frenching are in progress both at Canberra and at Katherine.

Blue mould in the field is a continuing source of loss in all areas. Several surveys of field occurrence in one area did not reveal any major cause for differences in severity of symptoms such as could be used as a basis for control.

(*d*) *Experiments in the Northern Territory.*—At Katherine Research Station, the testing of the levee soil for tobacco production was continued in collaboration with the Land Research and Regional Survey Section. There were three times of planting extending from the end of May to early July, the total area planted being four acres. Total yield per acre was satisfactory but the proportion of good-quality leaf was low. Approximately one-third of the crop showed evidence of excess nitrogen and was quite unsuitable for flue-curing. A disorder known as frenching was widespread, causing further loss in quantity and quality. Leaf texture was affected adversely by low atmospheric humidity and the same factor introduced difficulties in handling cured leaf. The 1,700 lb. of good leaf offered for sale at auction realized an average price of 127d. per lb., a very satisfactory result.

Experiments designed to obtain further information on nitrogen requirements and on the causes of the severe outbreak of frenching are in progress. A small test plot has been established at the Ord Research Station.

9. TOBACCO CHEMISTRY.

(Division of Plant Industry.)

(*a*) *Trashy Leaf Phenomenon in Tobacco.*—The prevalence of trashy leaf is causing a considerable loss to the Australian tobacco industry. The affected leaf is mainly characterized by loss of carbohydrates and increase in total nitrogen. Investigations have been extended to include study of qualitative and quantitative changes in composition of glass-house plants which are subjected to treatments conducive to trashiness.

Evidence exists that unfavorable energy status of a plant in terms of carbohydrate and nitrogen levels may lead to the phenomenon of trashy leaf in tobacco. This may also be responsible for unfavorable yields in other crops when grown out of their environment.

(*b*) *Fluorescence in Trashy and Non-trashy Leaf.*—Development of trashiness in tobacco is accompanied by decrease of fluorescent compounds in the affected leaf. This makes possible detection of degree of trashiness during sampling by observing differential fluorescence under ultra-violet light. The isolation and stability of the fluorescent compounds are being investigated.

(*c*) *Flue-curing of Small Samples of Glass-house Tobacco.*—The quality of flue-cured leaf depends on conditions of growth and culture of the plant as well as the curing process. For glass-house experiments flue-curing procedure is essential for assessment of quality in experimental leaf. The curing of small samples of leaf and an investigation of their chemical composition is proceeding at Canberra. It was found that a good quality flue-cured leaf could be grown in the glass-house and, for successful curing, samples need not be larger than one leaf, providing adequate humidity is maintained in the curing chamber.

(*d*) *Studies of Plant Sugars.*—Further qualitative studies of sugars (by paper chromatography) in plant materials indicated a large fluctuation in relative proportions of hexose and pentose sugars and aldo- and keto- forms. Thus, under conditions of environmental strain or disease, pentoses may accumulate, and tobacco samples have been obtained which contain up to 2 per cent. of arabinose. Special attention was given to the differentiation of keto- from aldo-sugars. A new specific reagent capable of identification of 5 μg of keto-sugar was developed for the purpose.

The presence of leaf-roll virus has a large quantitative effect on the carbohydrate status of the potato plant and the fluorescence in the stems. Present work is directed to the quantitative and qualitative fluctuations in individual sugars and total carbohydrates occurring during progress of disease in infected plants.

10. PLANT NUTRITION.

(Division of Plant Industry.)

(*a*) *Characterizing Deficient Soils.*—Trials with potassium, copper, zinc, molybdenum, manganese, iron, magnesium, and boron on a number of soils on the Southern Tablelands of New South Wales are being maintained. Responses to nitrogen, phosphorus, sulphur, calcium, molybdenum, and boron have been identified in this area.

In trials at the F. D. McMaster Field Station at Badgery's Creek, a problem of symbiotic nitrogen fixation has been discovered. Legumes fixed little nitrogen and responded markedly to nitrogenous fertilizer. Lime improved the colour and growth of legumes on this soil.

(*b*) *Factors Affecting the Supply and Availability of Elements in the Soil.*—(i) *Effect of Clover.*—An experiment to determine the effect of subterranean clover on the nitrogen status of soil is being continued at Canberra. The effect of the clover on the yield of a cereal crop will be measured.

(ii) *Combined Effects of Clover and Fertilizer.*—The trials on the effect of superphosphate on clover and subsequent development of grass are being maintained for a second period of four years.

(iii) *Soil Reaction.*—The effect of lime in increasing yields of clover has been examined. Information has been obtained on the role of lime on some of the soils of the Southern Tablelands and at the Heytesbury Forest area in Victoria. Some of these trials are being maintained to examine later effects of lime.

(iv) *Nodulation and Nitrogen Fixation.*—It has been shown that normal nodulation of clover can be obtained on acid soils on the Southern Tablelands by drilling inoculated clover seed with only 2 cwt. of lime per acre. The role of lime in improving nodulation is being examined.

(*c*) *Factors Affecting the Response to Fertilizers.*—(i) *Interactions between Elements.*—Information on the interaction between elements has been obtained in many experiments. Long-term experiments to study the interaction between phosphorus and sulphur are being maintained.

(ii) *The Residual Effect of Fertilizers.*—Field experiments with fertilizers are being maintained to obtain further information on the residual effects of the different elements. Information on residual effects up to six years have been published.

(iii) *Form of the Fertilizers.*—The shortage of sulphur for the manufacture of superphosphate has stimulated work on rock phosphate. Responses to rock phosphate have so far been considerably less than responses to superphosphate, even where sulphur deficiency is corrected. The trials will be maintained for several years to determine subsequent effects.

(iv) *Fertilizer Placement.*—Trials to determine effects of lime and copper placement on the soils of the Heytesbury Forest area have been laid down.

(*d*) *Characterizing Deficient Plants and Defining the Role of Elements in Plants.*—(i) *Mineral Content.*—Information on the differences in the nutrition of various plant species is recorded in the experiments.

(ii) *Organic Constituents.*—Deficiencies of a number of the elements influence protein metabolism. Work has been commenced to study the effect of deficiencies of essential elements on the amino acid composition of plants.

The effect of deficiency of molybdenum on the nitrate, ammonia, amide, amino acid, and protein content of plants is being studied. The molybdenum treatment is applied from one hour to three days before harvest. The results so far suggest that molybdenum is especially needed for the initial reduction of nitrate.

(iii) *Biochemical Reactions.*—Studies on the *in vivo* effect of molybdenum on phosphatase activity are being continued. Lower molybdenum concentrations than those previously used are being tested to minimize the influence of inorganic molybdenum. Previous work has shown that molybdenum inhibits phosphatase activity *in vitro*.

(iv) *Symptoms.*—Symptoms of deficiencies obtained in the course of the work are photographed and described.

11. Mineral Nutrition of Plants.

(Division of Biochemistry and General Nutrition.)

The large-scale development which has followed the solution of the overall nutritional problem in the Ninety-Mile Plain, has revealed many subsidiary problems associated with particular soil types, some of which have been subjected to experimental investigation. Broadly, the initial problems are the same in each case: deficiencies of phosphorus, nitrogen, zinc, and copper have been found to vary in degree according to the soil type, and so marked differences in species adaptability have become apparent.

A programme of work has been initiated which aims at providing information of a more detailed character which should simplify the solution of these subsidiary problems. This will entail more intensive work under controlled conditions of the glass-house rather than extensive field studies such as have been conducted in the past. The need for this basic detail has been stressed by the frequency with which uncertainties arise in complex field experiments; and the stage has been reached at which the Division can make its best contribution to pasture development in the Coonalpyn Downs by investigating intensively the plant's nutritional requirements of zinc and copper and the function of these minor elements in the general physiology of plants.

The greater proportion of the subsidiary problems in this area are such as may be solved by intelligent application of knowledge already provided by the Division. Some of those which concern the whole area are, however, being studied with the help of field experiments.

A series of experiments have been initiated to provide basic knowledge of the factors which control the uptake of cobalt by plants. It is unlikely that plants require this element for their own function. This point, however, is being investigated.

12. General Chemistry.

(Division of Plant Industry.)

(*a*) *Chemical Techniques.*—(i) *Determination of Sulphur in Soils.*—A method has been developed for the rapid determination of total sulphur in soils. This method depends upon the fusion of 0.5 g of 50-mesh soil with 1.4 g sodium peroxide in a nickel crucible. The cooled melt is then dissolved in hydrochloric acid and iron and aluminium precipitated as hydroxides by the addition of ammonia. These are then removed by centrifuging. Sulphur is then estimated in the supernatant liquor as barium sulphate by turbidity measurement after adjusting the pH.

(ii) *Determination of Molybdenum in Soils.*—A method for the determination of molybdenum in soils is being investigated.

(*b*) *Nutrient Availability.* — (i) *Sulphur.* — The chemical factors concerned in the availability of soil sulphur to plants are being investigated. Examination of a number of soils from eastern Australia from areas of moderate to high rainfall show very low free sulphate sulphur. The total sulphur in these soils is correlated with total carbon and nitrogen which appears to indicate that, in general, the greater proportion of sulphur in these soils is organic in nature. The carbon : sulphur ratio has been found to vary from 41 : 1 to 177 : 1 with an average value of 103 : 1.

The total soil sulphur shows some relationship to the sulphur taken up by plants in pot culture experiments, but this relationship is poor and there is an influence of soil type.

(ii) *Phosphorus.*—By successive extraction of soils with acetic acid and sodium hydroxide it is possible to estimate two available fractions of soil phosphorus, which can be used as an index of phosphorus availability on any one soil type provided correlations are first made with field or pot culture responses. The absolute availability of these fractions, however, is governed by a number of soil factors such as pH, phosphate adsorption capacity, and the exchangeable cations. The interactions of these chemical factors on he absolute availability of the soil phosphorus as measured by plant uptake are being examined so that the method can be adapted to conditions which will be independent of soil type and intersoil variation.

(iii) *Molybdenum.*—The availability of molybdenum to the plant is influenced markedly by the soil pH. However, other soil factors also influence molybdenum availability considerably. Glass-house and laboratory experiments are being conducted to investigate these, particularly the absolute amounts of molybdenum and the nature of the free iron oxides present in the soil.

(iv) *Manganese.*—Although the chemistry of manganese in soils has been widely studied, it is not known how the available oxides persist in soils. Laboratory and pot investigations are in progress on the reactions of manganese in both healthy and efficient soils, particularly (1) the non-biological reduction of manganese dioxide in soils to see if there are differences in reducing ability or organic matter, and (2) the adsorption of the manganous ion by solid phase components of soils.

(v) *Utilization of Copper by Oats.*—An examination is being made to determine whether varieties of oats differ in the efficiency with which they utilize copper within the plant and hence whether they could tolerate differing severities of copper deficiency. Four varieties of oats (*Avena sativa*), Rotenburger oats (*A. strigosa*), and rye cereal (*Secale cereale*) were grown in the glass-house on a normal and a copper deficient soil. Harvests were made at the flowering stage and at maturity. Analyses are being made of the leaf, stem, and grain of these plants to determine the concentration and distribution of copper within the plant. Analyses are not yet complete, but those so far available indicate that, although there were differences in the visual symptoms of copper deficiency between the four different varieties of oats, there appears to be little difference in the uptake of copper from the deficient soil or in the copper contents of the individual plant parts. All failed to set grain on this soil. On the other hand the Rotenburger oats and the rye cereal each had a greater copper uptake than the oat varieties, both from the copper deficient and from the normal soil. The amounts of copper taken up by the plants were—from the copper deficient soil, *A. sativa,* 6-7 μg Cu; *A. strigosa,* 12 μg; and *S. cereale,* 10 μg per plant; and from the normal soil 24-30 μg, 50 μg, and 30 μg respectively.

13. PLANT ECOLOGY.

(Division of Plant Industry.)

(*a*) *Regional Vegetation Surveys.*—Surveys for the purpose of classifying and mapping plant communities are in progress in the Southern Tablelands, Macquarie, and New England regions of New South Wales, south-western Queensland, and the rain forest regions of Queensland and northern New South Wales. The survey in New England is nearing completion, the major plant communities have been classified and part of the area mapped. Reconnaissance surveys in the Macquarie region have been completed and species lists compiled for twelve major plant communities. Soil-plant interrelationships on part of the south-western Queensland region have been determined, and a paper embodying the results of this work will be published shortly. The surveys in the rain forest and the Southern Tablelands are in the initial stages.

(*b*) *Studies on Native Grasslands.*—(i) *Ecological Studies on Treeless Grasslands.*—Studies of the distribution of treeless grasslands in south-eastern Australia in relation to soil, climate, and fire are in progress. Particular attention is being devoted at present to the subalpine grasslands of the Monaro region. These investigations include studies on the origin of the treeless areas as well as the changes in their botanical composition as a result of grazing and disturbance by man. An experimental area has been established at Seventeen Plain in the Kosciusko Park Trust Area, for detailed studies.

(ii) *Grazing Management Experiment, Trangie, New South Wales.*—This project is being conducted in co-operation with the New South Wales Department of Agriculture, and is designed to obtain information concerning the proper management of semi-arid *Stipa-Chloris* pastures. The effect of various stocking rates and systems on the yield and persistence of the perennial grasses and the wool production and liveweights of Merino wethers is being studied.

The favorable climatic conditions during 1952-53 tended to reduce any differential effect of stocking rates but the heaviest rate tended to reduce the production of green feed and this was reflected in the wool yields of sheep from such treatments.

(iii) *Autecological Studies on Native Grasses.*—Detailed life-history studies of four native perennial grasses and three winter annuals have been completed. Information was obtained on germination, seedling establishment, seasonal production, seed production, and root development.

A study is in progress of the incidence of *Bothriochloa ambigua* in the *Danthonia* pastures of the Southern Tableland and its relationship to grazing and erosion.

(*c*) *Ecological Studies on Weeds.*—(i) *Skeleton Weed* (Chondrilla juncea).—A survey of the distribution of skeleton weed has been completed and the area has been mapped. Within the climatic limits of its distribution skeleton weed density appears to be strongly correlated with the degree of soil disturbance.

The effect of competition from introduced pasture species on the growth of skeleton weed is being studied at Cowra, New South Wales, and Canberra, Australian Capital Territory. The results of the first year's work indicate that subterranean clover is the most effective competitor of the species used. Detailed studies of the factors involved in competition between skeleton weed and pasture plants of different growth habits are under study at Canberra.

(ii) *Hoary Cress* (Cardaria draba).—The role of Wimmera ryegrass and other pasture species in the control of hoary cress by chlorinated phenoxyacetic acids is being investigated at Murtoa, Victoria.

(iii) *Relationship of Fertilizers and Weeds.*—The effect of annual applications of nitrogen, phosphorus, and potassium on the winter weed population under citrus trees at Griffith, New South Wales, was determined. Grasses predominated where nitrogen and phosphorus were added, medics were phosphorus alone, and capeweed (*Cryptostemma calendulaceum*) where nitrogen alone was applied.

(iv) *Distribution of Introduced Weeds in South-east Australia.*—The distribution of introduced weeds in relation to climate, soil, and land use is being studied. The general distribution of the principal weed species of Victoria has been determined and this is being related to environmental factors.

(v) *The Ecology of Aquatic Plants.*—During 1952 a study was commenced of the distribution of aquatic plants in irrigation channels in relation to such factors as water depth, channel cross section, turbidity of the water, and rate of water flow. A preliminary reconnaissance of irrigation channels in north-west Victoria and in the Murrumbidgee Irrigation Area has been completed. This work should assist in formulating methods of controlling those aquatic plants which impede water flow during the irrigation season.

(*d*) *Ecology of Rain Forests.*—The Australian rain forests possess unique features which make them of considerable interest to botanists both here and abroad. In spite of the fact that Australian rain forests have been utilized for timber production for many years, very little is known of the interrelationships of the individual species or of the ecological relationships of the communities concerned.

14. PASTURE INVESTIGATIONS AT CANBERRA, AUSTRALIAN CAPITAL TERRITORY.

(Division of Plant Industry.)

(*a*) *Species and Strain Investigations.*—(i) *Subterranean Clover.*—The plant collecting expedition to the Mediterranean area in 1951 provided some 60 collections of *Trifolium subterraneum* from sites extending from Turkey to French Morocco. These were the first introductions from the Mediterranean area to Australia in which full details of the habitat and mode of occurrence were known.

In 1952 rows of single plants of each of the introductions and of some 60 of the varieties previously collected under field conditions in Australia were planted at Canberra, Australian Capital Territory, and at Kojonup, Western Australia. Detailed quantitative and qualitative observations were made on all plants. The objective was threefold. Firstly, it is hoped that these new introductions may provide material of direct commercial value in Australia; secondly, the comparison of the "Australian" and Mediterranean material may permit some deductions regarding the origin of the Australian varieties, whether by independent introduction or by evolution in Australia; and thirdly, it permits comparison of material from various parts of the Mediterranean basin. The range of maturity of the whole Mediterranean collection exceeds that of the Australian material, but the range of maturity from any particular zone in the Mediterranean is relatively restricted.

(ii) *Annual Medics.*—In conjunction with the New South Wales Department of Agriculture, long-term trials have been in progress to determine whether suitable annual medics can be found for the wheat and sheep areas where conditions are unfavorable for subterranean clover.

The trials at Wagga, Temora, and Crooble have shown that a strain of *Medicago tribuloides* (No. 173) is superior to all others so far tested. It is now to be certified by the Department of Agriculture and arrangements have been made for commercial production of seed.

Further co-operative trials have been established at Condobolin and Trangie, which are further west than the trials previously undertaken.

An investigation of soil factors influencing the relative development of medics and of subterranean clover is being conducted at the Temora Experiment Farm to secure more precise information on the soil requirements of each. The information from this trial should permit a more accurate definition of those areas where each can be most usefully employed during the pasture phase in the wheat rotation programme.

A study of factors influencing the production of hard seed in medics showed that while seed dehydration exerts a major influence on development of impermeability in the seed coat, the amount of nitrogen available to the plant during its period of growth is also significant, a higher level promoting more hard seed formation.

A number of new introductions of medic species and strains collected by the Mediterranean expedition are being examined at the Dickson Experiment Station and compared with material previously obtained from Australian and overseas sources.

(iii) *Grasses.*—*Phalaris tuberosa* and Wimmera ryegrass are the standard sown grasses in the Southern Tablelands environment. Many other species are under test, and those which appear promising are cocksfoot, *Bromus inermis*, *B. unioloides*, *B. marginatus*, *B. coloratus*, and *Festuca arundinacea* (Kentucky 31). The work aims to determine whether these species can be most effectively used in combination with the standard species or whether they are best grown in alternate mixtures.

To date none of the newer species has out-yielded the standard species but there are indications that with increasing soil fertility some of them may prove superior at certain times of the year. So far the addition of various grass species to a mixture of *Phalaris* and subterranean clover has tended to depress the total yield although increasing the proportion of grass to legume.

A trial to study the influence on production of herbage from *Phalaris tuberosa* when drilled in 7, 21, or 35 in. spaced rows, growing in association with subterranean clover, has shown that although the grass production per acre from the standard 7 in. drill rows has at first been greater than the wider spacings, the difference is becoming progressively less owing to the relative increase in vigour of the plants at wider spacing. The production of the subterranean clover has varied inversely with the grass production so that there has been little significant difference between total production of herbage from any of the treatments at the end of the growing season. The sowing of *Phalaris* in widely spaced rows means a considerable reduction in cost of establishment.

(*b*) *Fertility Studies.*—(i) *The Rate and Nature of Fertility Lift by Subterranean Clover*—During the past 30 years, "improved pasture" in southern Australia has attained an estimated area of 22,000,000 acres. In all instances it has involved the use of superphosphate and a suitable legume, principally subterranean clover. Trace elements, copper, zinc, and molybdenum, are required as additional fertilizers over considerable areas. In many regions, the practice has not been aimed only at fertility maintenance or the achievement of some degree of improvement, but rather at the conversion of poor and even worthless land to a high degree of productivity. There are few instances in the world of so dramatic an improvement in fertility and productivity over such extensive areas as those now being developed by the use of sown pastures in these cool and warm temperate regions of Australia. Yet little is known of the rate or character of this fertility lift.

A project commenced in 1952 aims at the detailed study of this phenomenon. A survey has been made of the fertility status of 45 paddocks of varying top-dressing history on the granitic sandy loams of the Crookwell-Binda area, New South Wales. Fertility has been assessed both through the growth and response to applied nutrients of oats in pot culture on each of the soils and by the chemical analysis of the soil and the oats.

The untreated soils of the region are seriously deficient in phosphorus, sulphur, and nitrogen; the first two of these elements are supplied in the superphosphate, the nitrogen through the rhizobial activity of the subterranean clover. The survey has shown that deficiency of each of these elements is largely but not fully met after 25 years of clover involving application of 13 cwt. of superphosphate. The increase in nitrogen content of the soil shows close linear relationship to the readily extractable soil phosphorus over all 45 paddocks examined, with an increase of soil nitrogen from 0.05 per cent. in the untreated paddocks, still carrying native pasture, to 0.20 per cent. in those with the longest history of improvement. Of the applied phosphorus, approximately half occurs in the acetic acid soluble and sodium hydroxide soluble fractions, the balance in the organic form. Soil analysis also shows that the ratio of the increase in soil sulphur and the increase in soil phosphorus due to superphosphate application is almost precisely the same as that of the applied fertilizer, suggesting that sulphur is as insusceptible to loss by leaching or other means as phosphorus is already known to be.

Studies are continuing both on this soil type and on two other soil types—those of basaltic and of sedimentary origin—within the region.

(ii) *Influence of Pasture Species.*—A trial has been established to determine the influence of individual species of grasses and legumes growing in pure culture on soil structure measured in terms of aggregation and pore space. The species under trial are *Phalaris tuberosa,* perennial ryegrass, Wimmera ryegrass, subterranean clover, red clover, and lucerne.

At Temora and Wagga, areas, on which various species and strains of medic and subterranean clover have been growing in association with Wimmera ryegrass for a period of three years, are being cropped with wheat to determine their influence on the yield of the cereal crop.

A trial to determine the influence of volunteer pasture subterranean clover and a mixture of *P. tuberosa* and subterranean clover for various periods of time on soil fertility measured in terms of subsequent wheat yield is in progress at the Dickson Experiment Station.

(iii) *Nitrogen and Phosphorus Turn-over by Pasture and Animals.*—The carrying capacity of a mixed pasture is not only related to level of soil fertility but to the rate at which nutrients go through the cycle of soil-plant-animal and back to soil again. The rate of uptake of nitrogen and phosphorus and the competition for these nutrients by Wimmera ryegrass and subterranean clover is being measured on soils with varying levels of these nutrients. Yield data indicate that six weeks' initial growth of subterranean clover seedlings, prior to germination of Wimmera ryegrass on the same soil, practically nullified response by the ryegrass to an initial application of 30 lb. of elemental nitrogen per acre. Thus, the competition by the clover for nitrogen is of undoubted significance in a mixed pasture of these two species.

(iv) *Nutrient and Light Competition.*—Studies of the component factors of the competition between pasture plants are being continued. A specially designed pot culture has permitted for the first time a study of the relationship of competition for light and for nutrients. They are closely interdependent phenomena but it is only by their study as separate and interacting factors that a full appreciation of their significance is possible. Their interaction is a variable phenomenon, depending on such factors as fertility status and stage of growth.

(*c*) *Management.*—(i) *Conservation Effect on the Animals.*—Though improved pastures under continuous grazing can give more than threefold increases in wool production or sheep liveweight production or both over untopdressed native pasture, this is achieved under a system that allows up to 50 per cent. of the feed produced to be left unconsumed by the animal. Though the nutrients in this unconsumed herbage are not necessarily lost to the soil, they could be used to better advantage if returned through the animal as conserved fodder. Various degrees of pasture conservation and therefore of utilization are being compared in a long-term trial in which five equal areas are each carrying the same number of sheep continuously but in four of them various proportions are shut up during the spring time for fodder. The sheep are then maintained on the herbage production on the balance of each area until such time as their body weights indicate that they are getting insufficient feed, when the conserved fodder is fed back to them as required.

During the first twelve months of the trial each treatment carried four sheep per acre and even where two-thirds of the paddock was shut up and 6 cwt. of hay conserved per head, the sheep gained as much weight as those on the treatment where sheep had the run of the full grazing area and more was set aside for fodder conservation.

(ii) *Conservation Effect on the Pasture.*—Measurements of pasture growth rate are being undertaken to determine the reaction of the pasture to the various intensities of grazing operative in the previous trial during the period when various portions of the grazing areas are set aside for fodder conservation.

On another trial, surplus spring growth is being taken off for silage or for hay, and the regrowth of pasture the following year related with the method of conservation and its productivity. The results so far indicate no depression in total autumn, winter, or spring growth during the year following the removal of the surplus spring growth. Though the grass was reduced in vigour and production, this was compensated by a greater production by the clover component.

15. Pasture Investigations at Armidale, New South Wales.

(Division of Plant Industry.)

(*a*) *Ecological Surveys.*—(i) *New England Region.*—The mapping of this region is being continued. The following great soil groups have been shown to occur in the area—krasnozem, prairie soil, black earth, and lateritic kraznozem on the basalts; red and yellow podzolic and lateritic podzolic soils on the granites and sedimentary rocks.

Savannah woodland and forest formations dominated by species of the genus *Eucalyptus* (47 species occur in the area mapped to date) characterize the native vegetation. The area is one of active eucalypt speciation, suspected hybrids being a common occurrence. A number of native pasture types have been recognized in which *Poa caespitosa, Sorghum leiocladum, Agropyron scabrum, Bothriochloa ambigua, Dichelachne sciurea, Danthonia* spp., and members of the Juncaceae and Cyperaceae are important.

(ii) *South-western Queensland.*—An area of 4,000 square miles, representative of the general area included in this survey, has been mapped in detail. Fourteen vegetation associations have been recognized and mapped as association complexes. Six great soil groups have been identified and mapped. The climatology of the area has also been studied and information collected on the effect of management practices on the native pastures.

In addition a detailed field reconnaissance of 20,000 square miles has been undertaken and the soils and plant-soil relationships studied.

(*b*) *Autecological Studies of Native Pasture Species.*—The following information is being collected on a number of native pasture species: (i) general phenological record; (ii) seasonal growth under conditions of measured soil moisture; (iii) seasonal changes in chemical composition; and (iv) effect of burning at monthly intervals throughout the year.

One year's observations on the effect of burning have shown that with early burning (June) the basal area of all the major species in the pasture has decreased. However, the number of plants of red grass (*B. ambigua*) has increased.

(*c*) *Grazing Management Studies of Native Pastures.*—(i) *Comparison of Rates of Stocking and Continuous v. Rotational Grazing.*—In co-operation with the Division of Animal Health and Production (*see* Chapter VII., Section 21 (*b*)) a study has been made of the effect on the sheep and the effect on the pasture of different rates of stocking. Records were obtained of the effect of the different grazing treatments on: (i) infection by internal parasites; (ii) wool production; (iii) liveweight of the sheep; (iv) yield and botanical composition; and (v) chemical composition of the pasture.

The experiment, which commenced in November, 1948, was concluded in November, 1952. No significant differences in the amount of forage available under light (one sheep to 1¼ acres) and medium (one sheep to 1 acre) rates of stocking have been recorded during the course of the experiment. Under a heavy rate of stocking (one sheep to ¾ acre) the yield of forage has been consistently lower. No differences have been recorded in the amount of forage available under rotational (one week in four) and continuous grazing at a rate of stocking of one sheep per acre.

(ii) *Studies on the Production of Native Pastures used in conjunction with Sown Pastures.*—The results of the preceding experiment and general observations on sheep production on the native pastures of the New England region have shown that even at relatively light rates of stocking sheep weights decline to a low level in winter, and with stocking rates fixed by this critical winter period much of the summer production is not utilized. The critical winter period makes the breeding of Merinos solely on native pasture impracticable.

In co-operation with the Division of Animal Health and Production (*see* Chapter VII., Section 21 (*c*)) a study was commenced on the effect of supplementing the grazing on native pastures with the following percentages of sown pasture: (*a*) 59.1, (*b*) 30.8, (*c*) 15.5, and (*d*) 3.9. A breeding flock of Merinos is being used. With only small proportions of sown pasture available the supplementary grazing will be provided according to the requirements of each class of stock, that is, weaners will receive first preference.

(iii) *Studies of the Summer Management of Native Pastures.*—Under the relatively severe winter conditions of the New England region the maximum carrying capacity of the native pastures is limited to approximately one sheep per acre. At this rate of grazing the production of the pastures during the summer months is not all utilized and the aftermath is considered to reduce the capacity of the pasture to carry sheep during the following winter.

A study is being made in co-operation with the Division of Animal Health and Production of the effect of various management practices, designed to reduce the amount of aftermath at the end of the summer, on the winter carrying capacity of the native pastures. The management practices are: (*a*) grazing at one sheep per acre (control); (*b*) grazing at three sheep per acre; (*c*) ungrazed during summer; (*d*) grazing with sheep (one per acre) and cattle (one per 3 acres); (*e*) grazing with cattle (one per 3 acres); (*f*) mowing the pasture at the end of summer and removing the aftermath; (*g*) burning the surplus growth at the end of summer; and (*h*) surface seeding the native pasture with clover and grazing according to the forage available. Treatments (*f*) and (*g*) are grazed at the rate of one sheep per acre during the summer. During the winter months (April to November) all treatments are stocked with weaners at the rate of one per acre and their liveweight increase is used as a measure of the effectiveness of the above treatments in improving the winter grazing of the pasture.

During the first summer, commencing with the same amount of forage available in all paddocks, each group made a liveweight gain of approximately 12 lb./acre, that is, 12 lb. per head when grazed at the rate of on sheep per acre and 4 lb. per head when grazed at th rate of three sheep per acre. Having cattle grazing i addition to the sheep did not reduce the liveweight gai of the latter.

During the winter, weaners on the pasture that ha been ungrazed during the previous summer made th greatest liveweight gains. The liveweight gains of th groups that followed other summer management practices were not related to the varying amounts of forag remaining after the summer treatments, that is, at th beginning of their winter grazing period.

When forage was abundant both sheep and cattl grazed the same species, but when grazing pressur became severe cattle commenced to graze the talle tussock species before the sheep.

(*d*) *Improvement of Native Pastures.*—Previou investigations have demonstrated that, with the application of superphosphate, subterranean and white clover can be successfully established in dense native pastur without ploughing. Although the protein content of th native species and hence their forage value has bee raised by growing in association with clovers establishe in the above manner, the native species often do no persist in competition with the clovers and a pure stan of the latter results.

From the point of view of developing a balance highly productive pasture it would be advantageous t replace the native species with sown grass species and i this could be done by "surface seeding", that is without ploughing, costs would be reduced to a minimum. An investigation has therefore been commence of methods of establishing grasses in (*a*) native pastur and (*b*) native pasture into which clovers had bee previously incorporated.

(*e*) *Species and Strain Trials.*—The suitability o the New England region for highly productive improve pastures has been demonstrated by the extraordinar high carrying capacity of *Phalaris*-white clover an perennial ryegrass-white clover pastures. Two of thes pastures were stocked at eight Merino weaners to th acre continuously for twelve months. This resulted i a wool yield of over 62 lb./acre, a 10- to 12-fold increas compared with the comparable sheep on native pastures The liveweight gains were also considerably greater o sown pasture.

The testing of forage grasses and legumes is continuing and being extended into new localities. As th fertility of the soils is being improved by growth o clover, several grasses are yielding considerably mor than *Phalaris,* thus confirming the trend observed las year. *Festuca mairei,* several tall fescues, and perennia ryegrasses have been most prominent in this regar In a grazing trial on fertile soil, Wimmera ryegrass wa found to be superior in the seeding year to oats as forage crop.

Following the summer drought of 1951-52 the annua clovers, particularly crimson clover and Tallarook an Bacchus Marsh subterranean clovers, yielded considerably more than the perennial clovers. Howeve Ladino white clover, alsike, and red clover were quit productive. Lucerne yields appear to be restricted b faulty nodulation and when this is overcome bette results are expected with this valuable species.

Winter productivity of Tallarook subterranean clove was shown to be highly dependent on the time of sowing Yields at intervals through the winter were muc greater from early sowings than from those made only short time later.

A decline with age in the productivity of th Tallarook strain of subterranean clover, compared wit other strains of this species, has occurred in a five-year old pasture. The reasons for this are being investigate (*f*) *Plant Nutrition Studies.*—The survey of the plant nutrient status of New England soils has been extended to seven of the major soil types. First-season results from factorial field trials are available for three centres. At each, a marked deficiency of phosphorus and nitrogen was observed and at two of the three there was also a marked response to sulphur. Sulphur responses are greatly increased with the presence of phosphorus, or nitrogen, or both. Nitrogen was ineffective in two out of the three centres without added phosphorus, or sulphur, or both. Phosphorus was less dependent on the other two elements.

Potassium, limestone, magnesium, molybdenum, copper, zinc, iron, and manganese were without effect, but in one case boron appeared beneficial.

Rock phosphate has been shown to be a very poor source of phosphorus on a chernozem soil, 1 cwt. of superphosphate producing in the first year the same response as 16 cwt. of rock phosphate. (Sulphur supplies were adequate in both cases.)

Gypsum has proved a cheap and effective source of sulphur. On a basaltic soil in the Liverpool Ranges 1 cwt. of gypsum per acre resulted in a sevenfold increase in medic growth.

On established pastures previously fertilized with superphosphate, results have shown that pasture production may be maintained with additions of gypsum in place of annual dressings of superphosphate. This finding has considerable economic significance, and the conditions under which gypsum may replace superphosphate are under investigation.

The improved growth of plants on burns appears to be largely due to the increased supply of available nitrogen which follows the heating. The mineral constituents also appear to have some effect, and a trial is in progress to determine the important constituents in this regard.

A co-operative investigation with the University of Sydney School of Agriculture has been made of the unsatisfactory nodulation of certain clovers in the region. The soils on which the problem is more acute have been shown to contain very few naturally-occurring *Rhizobium* spp.; of those present, most are ineffective on subterranean clover.

16. PASTURE INVESTIGATIONS AT DENILIQUIN, NEW SOUTH WALES.

(Division of Plant Industry.)

(*a*) *Ecology of Native Pastures.*—Visits to the *Atriplex vesicaria* dominant communities to the north of Wanganella have been continued, and preliminary indications are that bush density is proportional to the depth of soil moisture penetration. Seasonal observations of the floristic composition in these communities has been continued, and seed of various *Atriplex* species collected.

The grazing trial on *Danthonia semiannularis* pasture has been continued. The low rainfall in July-August, 1952, reduced the yield of winter plants, but green pasture was available until late December because of heavy rainfall in October. A considerable number of perennial grass seedlings (*D. semiannularis*) was recorded, germination occurring during the winter period as in 1951. Germination in protected areas was once again less than in grazed treatment plots. Recovery has been slow following the heavy mortality of large plants in 1951. The demise of these plants has probably been due to waterlogging. It has been demonstrated that the soils supporting *D. semiannularis* may be poorly aerated during considerable periods in winter and early spring, when, owing to delayed drainage and swelling of the clay surface, the soils may contain moisture in excess of field capacity.

The summer species *Chloris truncata* and *Sporobolus caroli* appeared as annual plants because of the late spring rainfall. Studies have been made of the seasonal fluctuations in soil moisture beneath four typical natural pastures. These data, with such other physical characteristics of the soil as bulk density, clod density, aeration, and soil moisture volume at various tensions, and with qualitative observations on the phenology of the species, are providing an understanding of their occurrence in the pastures.

(*b*) *Plant Species and Strain Trials.*—Plantings made in rows and small swards with 140 species in 1950 and 1951 have led to the exclusion of a large number as unsuitable for use under irrigation. Complete phenological data were collected for each species. Yield and seed production were measured; root density and distribution were determined and root morphology described from excavated prisms.

The following summer legumes are now considered worthy of trial in grazed swards maintained under flood irrigation: Palestine strawberry clover, Ladino and Irrigation white clover. Among the grasses which are highly productive are *Pennisetum purpureum*, *P. typhoides*, *Sorghastrum* sp. (C.P.I. 11,856), *Sorghum almum*, *S. arundinacea*, *Echinochloa pyrimidalis*, and *Panicum coloratum*.

For the winter growing legumes *Vicia faba* (var. *minor*), *Lathyrus ochrus*, *L. cicera*, *V. atropurpurea*, *V. sativa*, *V. dasycarpa*, and the Clare, Yarloop, Bacchus Marsh, and Tallarook strains of subterranean clover are best. Of the cereals, oats and barley were very productive and *Phalaris aquatica*, *Lolium multiflorum*, *P. tuberosa*, *L. rigidum*, and *Bromus unioloides* are well worth further testing in grazed swards.

The need for a wider range of species and strains than that in common use in the Australian irrigation environment is obvious. Apart from their productivity on the more difficult soils, the species need to be selected for their ability to contribute to the structural amendment of the surface soils and to have a useful place in a pasture rotation for animal production.

The perennial grasses have not persisted well in the sense of contributing to grazing. The most useful grass species is Wimmera ryegrass, *Bromus unioloides* being the only other grass contributing as much as 6 cwt. of dry material in the season. Useful legumes may be ranked: Clare subterranean clover, Bacchus Marsh subterranean clover, *Trifolium hirtum*, *Medicago hispida confinis*, and *M. tribuloides*, with Clare subterranean clover producing about 14 cwt./acre and *M. tribuloides* about 3½ cwt./acre.

There is a distinct possibility that suitable legume-grass mixtures can be used for improving the natural pastures on the coarser levee soils with fertilizer application. Among these, two new introductions to this region are promising, namely, *M. hispida confinis* and *T. hirtum*. Two collaborative trials have been conducted with other species. One is an observational trial with a wide range of medics sown in rows under dryland conditions. All species have matured in this environment but *M. orbicularis* did not regenerate in the second season, presumably because of hard seed. The second compared a number of strains of safflower for yield under irrigation.

(*c*) *Root Growth and Soil Structure Studies.*—Studies are continuing with a range of irrigated pastures on a number of soil types. Three-year-old, irrigated, perennial pastures were found to have added 10 ton/acre of oven-dry macro-organic matter to a sandy loam soil. Over half of this material has been added to the top 3 inches of soil.

For any one pasture, as the macro-organic matter of the top 3 inches of soil increased, infiltration rate decreased. When comparison was made at common macro-organic matter and soil moisture contents, soils under co-dominant white clover-perennial ryegrass pastures were found to have higher infiltration rates than soils under lucerne dominant pastures.

The problem of establishing pastures under irrigation on the clay soils of the Riverina region are still not resolved, though the factor of sowing time in autumn and the need to establish with rainfall instead of flood irrigation is now understood. It is a belief among farmers that rice growing improves soils for pastures. It has been shown that the inundation of land, apart from rice-growing, improves the surface structure temporarily and leaches salts so that much better pasture establishment can be obtained. These benefits were striking in the first season.

This work can contribute to an understanding of the chemical and physical changes which can take place in the clay soils with inundation and the use of summer crops with a high water requirement. It fits into the pattern of work beginning with species selection for vigorous summer growth and with a species succession, or a rotation, ending with better structured soils and highly productive pastures.

(*d*) *Plant Nutrition.*—Phosphorus, nitrogen, micro-element trials were imposed on Wimmera ryegrass-subterranean clover, either as mixed or monospecific swards.

Response to superphosphate increased in the second season of application, yield increases of over 70 per cent. (contributed largely by the clover) being obtained at an application rate of 4 cwt./acre. Diffusible phosphate increased in both species where phosphate fertilizer was used.

Heavy applications of nitrogen fertilizers tripled the yield of ryegrass in a monospecific sward, but neither increased nor decreased the yield of subterranean clover when grown alone.

Micro-elements did not affect yields.

(*e*) *Irrigation Hydraulics.*—*Border Check:* During the 1952-53 irrigation season observations were made of the behaviour of four irrigating streams in geometrical progression mown and unmown bays under three conditions of initial soil moisture. The observation of each irrigation of each bay involved an average of 10 depth measurements at an average of over 20 points per bay.

Collation and interpretation of the data are not complete. The influence of cover appears to be very marked, and it is thought that it will be possible to establish a relationship between the rate of advance of the stream and the initial moisture content of the soil.

In conjunction with this experiment, observations were made of the temperature of the advancing and ponded irrigation water, as it is thought that this may influence the incidence of "scalding" of pastures. A preliminary experiment involving the observation of temperature rise in artificially ponded water held at three depths indicates that water temperature is more closely related to received radiation than to air temperature.

(*f*) *Furrow Irrigation.*—Experimental data have been re-examined and found to provide an encouraging starting point in the quantification of furrow irrigation relationships. A parallel theoretical analysis has been completed.

(i) *Infiltration.*—Fundamental theoretical studies of infiltration and unsaturated water movement are in progress. Collaborative work has been initiated with an officer of the Division of Building Research on the development of electrical circuit analogues to study these problems.

The assistance of the Section of Mathematical I struments has also been enlisted in the study of the problems.

(ii) *Evapotranspiration.*—Recently the Water Co servation and Irrigation Commission of New Sou Wales requested estimates of potential evapotranspir tion for the Riverina.

A method has been developed for the estimation evaporation and evapotranspiration from precipitatio data and astronomically computed radiation. In i present form this is largely empirical, and mu further work is needed. The method has been use in its present crude form to supply the Water Conse vation and Irrigation Commission with estimates annual evapotranspiration.

(iii) *Irrigation Probe.*—The experimental pr gramme with the modified Proctor penetrometer is co plete. The data have permitted the correlation betwee soil moisture and penetration to be investigated for range of probe loads. It appears that the best correl tion is achieved with a load of 80 lb.

17. Pasture Investigations in Western Australi
(Division of Plant Industry.)

(*a*) *Grazing Management Trial, Perth.*—This e periment involves a comparison of continuous an autumn-deferred grazing with Merino wethers on sown annual pasture. Four grazing seasons have bee completed. Sheep liveweight data for 1952-53 agai show that the continuous group suffer a more rapid lo in body weight on the dry feed available during t late summer. Soon after the opening rains, the shee on the continuously grazed pasture regained weig rapidly, as in previous years. However, the deferre group maintained a higher mean body weight throug out the growing season due, no doubt, to the greate quantity of feed which was available to them. Th proportion of Wimmera ryegrass was again muc higher, and that of *Bromus gussonii* much lower, unde continuous grazing. However, in 1952, unlike th previous seasons, the proportion of subterranean clove was somewhat higher in the continuous grazing trea ment and the proportion of capeweed somewhat highe in the deferred.

(*b*) *Grazing and Rotation Trial, Wongan Hills.*— This experiment is a co-operative project located at th State Department Research Station near Wongan Hill The second three years' pasture phase is now complet and the sheep were removed from the plots after thei liveweights and wool production had been measure As in previous years, the oat pastures and the legum pastures carried the sheep in better conditon and pro duced more wool than the volunteer pastures of brom capeweed, and *Erodium botrys.*

The second cycle of the trial will be completed b cropping the whole area to wheat. The fertility statu of the soil will then be shown by the straw yield an the quantity and quality of the grain produced.

(*c*) *Species and Strain Investigation.*—(i) Phalari tuberosa.—A study on the effect of row spacing o yields and persistence of spring sown *Phalaris* is bein continued at Glen Lossie Field Station, Kojonup. Yiel data from the 1952 growing season indicate that th yield per unit area is now somewhat greater in th widely spaced rows than on the sward and, where cul tivation was carried out between the well-spaced rows the yield was further increased.

(ii) *Subterranean Clover.*—The more promisin strains from the 1951 row trials were tested again i 1952 together with a number of new types from th Mediterranean collection. Promising strains for th Kojonup district have been planted again this yea for further observation and to build up enough see supplies for sward trials. Samples from these strains will be assayed for genistein content in connexion with the sheep infertility problem.

Sixty of the most likely strains from the test rows will be sown together in a pasture to determine their behaviour under plant competition and grazing.

A sward trial involving 15 selected strains is being continued. Yield data at the end of the 1952 growing season again showed the superiority in early winter production of a number of strains over the locally grown Dwalganup. Among the outstanding newcomers were Port Fairy, Hill's Small, Liége, and Gingin.

(iii) Trifolium cherleri.—Strains of this species collected in the Mediterranean area were grown in test rows at Glen Lossie Field Station. The material displayed a wide range of maturing dates and gave a high seed yield. Some of the strains appear to be worth testing under grazing as an admixture to pastures.

(*d*) *Cereal Investigations at Kojonup.*—(i) *Oats.*—In the oat grazing and recovery trials a number of unnamed crossbred oats from Wongan Hills Research Station yielded very well. Orient again showed its ability as a grazing and recovery oat, and a new introduction, Acacia, gave a high green yield although it is a little late maturing for recovery. Generally recovery was good and yields ranged from 40.2 to 57.6 bus./acre.

(ii) *Barley.*—Five barley varieties were included in a grazing and recovery trial. Of these, Atlas gave the highest grain yield, 60.5 bus./acre, and also gave a good yield of green material. Research gave the highest green yield, with the high grain yield of 53.5 bus./acre. All grain yields were within the range 52.4-60.5 bus./acre.

(iii) *Wheat.*—In the trial of early maturing varieties, Insignia 49 proved superior to both Gabo and Wongoondy this year, although the yields generally were not high (19.1-24.2 bus./acre). With the mid-season varieties, yields were higher, with Eureka and Yalta again the best. In the time of planting trial with wheat, Gabo and Wongoondy were superior to Eureka in the first, third and fourth plantings, but Eureka was equivalent to the early varieties in the second planting with 35.1 bus./acre.

Trials planted in 1953 include one with ten wheat varieties sown at two planting dates and a further trial with eight oat varieties and two barley varieties under three grazing treatments.

(*e*) *Plant Nutrition Studies.*—(i) *Pot Culture Trials, Perth.*—Studies of the factors affecting zinc responses in subterranean clover were continued. Results indicate that high levels of soil moisture increase the zinc requirement. Also a high level of available nitrogen appears to hinder clover in utilizing the zinc in the soil. Several sources of nitrogen were tried and all showed this effect. The available phosphorus level of the soil has also been found to markedly affect the utilization of zinc present in the soil. Applications of phosphorus equivalent to only ¼ cwt./acre of superphosphate produced definite symptoms of deficiency. This action of phosphorus appears to be more pronounced with the Dwalganup than with the Bacchus Marsh strain.

(ii) *Fertilizer Field Trial, Kojonup.*—A study has been commenced on the effect of season on zinc responses given by subterranean clover. This trial will continue for several years. Marked zinc responses were given under the seasonal conditions experienced in 1952.

Further investigations on the responses to sulphur by subterranean clover were made at Kojonup. Two trials carried out on Kojonup sand have failed to show the marked response to sulphur given on the Kojonup gravelly sand. Experiments have been extended to include the Boscabel gravelly sand to find whether the sulphur deficiency is related to the presence of lateritic gravel in the soil profile.

The effects of varying rates of superphosphate applied annually are still under examination. The residual effects of superphosphate on Kojonup gravelly sand decreased again in the third year after application. Applications of sulphate to the plots did not increase the declining yields, and the decrease appears to be due to continued fixation of the phosphate in an unavailable form.

A trial was conducted on Kojonup gravelly sand to measure the response in pasture growth given by varying rates of rock phosphate. An application of 4 cwt./acre of ground rock phosphate gave a yield of subterranean clover almost equal to the highest yield given by superphosphate.

(*f*) *Soil Fertility Studies, Kojonup.*—The soil fertility studies initiated in 1952 have been continued this season. Successful establishment of subterranean clover was attained on the virgin land used for the experiment. A second series was commenced in the trial dealing with the influence of the age and productivity of a subterranean clover pasture. Re-establishment of the pastures in the second year has been very uniform. Soil samples have been taken at the commencement and conclusion of each growing season. In the trial comparing a number of grain legumes, the area has been sown to wheat this season as the second phase in the legume-cereal rotation. The experiment dealing with the effect of continuous cereal cropping on an established subterranean clover pasture has been amended to include a stubble treatment including burring, cutting, and " turning in " of the wheat stubble.

(*g*) *Pasture Ecology.*—Small exploratory trials have been carried out to determine the effects of grazing, fertilizing practice, and seasonal conditions on the botanical composition of the annual pastures at Perth.

18. PASTURE INVESTIGATIONS AT BRISBANE AND LAWES, QUEENSLAND.

(Division of Plant Industry.)

(*a*) *Ecology.*—The ecological survey of the coastal region from Brisbane to Bundaberg was continued. In collaboration with Dr. Lincoln W. Ellison, of the United States Forest Service, a study was made of the movement of the soil mantle in some of the higher rainfall areas of south-eastern Queensland. There is a considerable mantle movement under virgin forest and the landslips so common in these areas are not solely the result of clearing of the forest.

(*b*) *Regional Trials.*—(i) *Coastal Soils.*—The main centre for work on the low fertility coastal soils has been established at Beerwah in a perched tea tree swamp. Soil is a low humic gley and the annual rainfall approximately 55 inches.

Two experiments on the newly cleared virgin forest were planted in 1952. Eight grasses, *Paspalum dilatatum*, *P. scrobiculatum*, *P. simplex*, *P. regnellii*, *P. plicatulum*, *P. notatum*, *Panicum maximum* var. *trichoglume*, and *Brachiaria purpurascens* were sown in small swards with each of three legumes, *Desmodium uncinatum*, *Indigofera endecaphylla*, and *Stylosanthes bojeri*. Five grasses and fourteen legumes were sown as pure stands in small swards. Nineteen other species were also sown.

Establishment from seed was satisfactory in most cases, but growth and development of the legumes was severely retarded, partly owing to difficulties in obtaining satisfactory nodulation. Grasses were satisfactorily established and encouraging growth made where both phosphate and nitrogen supplies were adequate. Grazing of the mixtures has not yet been possible but will be undertaken during next season.

Additional tests on the coastal areas are being made at Glasshouse on an area of cleared and drained tea tree swamp, the soil being an organic clay (humic gley) already carrying a sod of *Axonopus affinis* and *Paspalum dilatatum.* A nutrient trial and a species trial were laid down. The species trial consisted of replicated swards of 40 legumes and 20 grasses. As in the Beerwah tests, the legumes suffered from poor nodulation, though species within the cowpea cross-inoculation group gradually developed well. In particular, *Phaseolus lathyroides* and *Desmodium uncinatum* showed promise. After inoculation with an effective strain of *Rhizobium, Trifolium repens* also grew splendidly.

Similar species and nutrient tests were made at Elimbah on light sandy soil of low fertility. Poor nodulation of legumes was again encountered.

Representative soils of the coastal region have been sampled by the Soils Division and are now being described and analysed (*see* Chapter II., Section 2).

The existence of water-tables over extensive areas of the coastal plain is of considerable importance in the study of the development of these areas. Ground water cells have been established at eight points near the experiment sites and fortnightly records of water levels made.

A detailed rainfall map of south-eastern Queensland is being prepared, the period for normals of 1921-50 being chosen after consultation with the Commonwealth Meteorological Branch. The main work at present lies in establishing correlations and homogeneities between stations of short records with those of full records, so that greater use can be made of the short record stations in plotting the isohyets.

(ii) *Spear Grass* (Heteropogon contortus) *Region.*—*Nutrient studies:* Further pot culture studies of the soil from Rodd's Bay have confirmed phosphorus deficiency, but response to other elements is not definite. Calcium has given significant yield increases with *Phaseolus lathyroides* and *Medicago sativa* in several instances, but in one case a significant depression in the yield of *P. lathyroides* due to calcium was noted. Similarly with potassium and molybdenum increased yield and decreased yields have been recorded. In all instances, however, the effects of the other nutrients are relatively small, while the effect of phosphorus is very great, indicating that by far the most important deficiency is that of phosphorus.

Species trials: A nursery trial was laid down at Rodd's Bay in 1952 as the first step in the assessment of pasture species in this region. Rainfall from February, 1952, has been good and particularly well distributed through the winter and spring and better than normal growth conditions have been experienced. The performance of the various species must, therefore, be regarded with reserve. The most promising species to date are as follows:—

Pasture legumes—*Stylosanthes gracilis* (C.P.I. 5630 and C.P.I. 9215), *S. bojeri* (C.P.I. 10983), *S. sundaica, Desmodium uncinatum* (C.P.I. 8990 and 11741), *Medicago sativa, Phaseolus lathyroides.*

Browse legumes—*Cajanus bicolor* (C.P.I. 11380, 12141, 11911).

Grasses—*Paspalum scrobiculatum, P. dilatatum, P. plicatulum* (C.P.I. 2741), *P. notatum* (C.P.I. 9212), *Chloris gayana, Panicum maximum* var. *trichoglume, Cenchrus ciliaris, C. setigerus, Brachiaria mutica.*

The most important observation made in 1952 was that in the winter months with ample soil moisture all the species under test remained green and continue to grow, whereas the native species were just as dr and dormant as in a more normal year.

Following on from the nursery row studies, a larg trial has been commenced consisting of swards of singl species and of grass-legume mixtures, which are to b grazed intermittently. The objective is assessment o the species with particular stress on compatibility o the various grasses and legumes.

Native pastures—studies of burning: Since 1945 a area of native pasture at Lawes has been subjected t various burning and mowing treatments, and observa tions have been made on changes in the botanica composition. Changes have been relatively slow, bu the treatments appear to be leading to the developmen of three distinct pasture types. Burning has produce a pasture in which *Heteropogon contortus* is ver dominant and in which the soil surface between th clumps of this species tends to be bare and hard. Wit mowing and raking, *H. contortus* is still dominant bu other species, especially *Bothriochloa intermedia,* ar prominent. Where the grass is not touched, or wher it is cut and left on the ground, *H. contortus* appear to be decreasing whilst *Sporobolus elongatus* is increas ing, and the heavy layer of litter appears to be leadin to a reduction in basal ground cover of living plants.

Grazing management—alternate pastures: For th past three years an experiment has been conducted a Lawes involving a comparison of steers grazing a mixe pasture of Rhodes grass and lucerne and steers grazin an equal area of which half is Rhodes-lucerne mixture one quarter is row-lucerne, and one quarter is *Paspalun scrobiculatum* reserved for grazing between May anc December.

Differences between the treatments were consistentl in favour of the alternate pastures, but they were no large, and at no time was there any major differenc in trend of weight change. Results on both treatment were very good in that the weight gains produce would, in practice, permit steers to be marketed a three years of age instead of the normal four to fou and a half years. The main reason for this was tha stock gained weight in winter instead of losing.

(*c*) *Plant Nutrition.*—(i) *Darling Downs.*—Th studies on the black soils of the Darling Downs hav now been completed. Nitrogen and sulphur are th primary limiting plant nutrients. Secondary bu minor responses to copper and zinc occurred. Chemica analyses of *Trifolium repens* grown on these black soil in the presence and absence of added sulphur gave th same copper content, but a reduction in zinc conten in the presence of sulphur. The zinc values at 27.1 and 34.81 p.p.m. are relatively low. Manganese conten increased with sulphur treatment from 45.0 t 64.7 p.p.m.

(ii) *Coastal Soils.*—Investigation of the nutrien status of the soils at Beerwah, Glasshouse and Elimba was an important phase of the work in 1952-53. Bot field and pot culture studies were made. Attention wa given to evaluating superphosphate, rock phosphate and basic superphosphate as the source of phosphat for *Paspalum dilatatum, P. scrobiculatum,* anc *Trifolium repens* on the Beerwah soil. The soil a Beerwah is extremely deficient in phosphate and al species fail to survive for more than a few weeks afte germination, unless phosphate is applied.

The field tests of nutrients other than phosphate wer based on four blocks: 1. *Paspalum scrobiculatum* anc *Phaseolus lathyroides* mixture; 2. *Paspalum dilatatun* and *Phaseolus lathyroides;* 3. *Trifolium pratense* 4. *T. fragiferum.*

Paspalum dilatatum responds to phosphate alone, but *. scrobiculatum* responded to a combined dressing of opper and zinc and interactions have been obtained etween phosphate and copper + zinc; phosphate and otassium; phosphate and molybdenum.

The clovers on blocks 3 and 4 gave poor growth ecause of inadequate nodulation, but subsequent inocuation with more satisfactory strains of *Rhizobium* has artly overcome this. Calcium at 4 or 10 cwt./acre aCO_3 doubled the yield of the clovers; while potassium nd a dressing of copper + zinc both gave 20 per cent. ncreases in yield. Molybdenum gave a positive ncrease in the presence of high phosphate.

Parallel pot culture tests fully agree with the results btained in the field and it was shown that copper is he element giving the response in the copper + zinc reatment used in the field tests.

A similar set of experiments have been made at lasshouse. *Desmodium uncinatum,* in the absence of hosphate, gave negligible yields which were increased 20-fold by 6 cwt./acre superphosphate. *Stylosanthes ojeri* and *Phaseolus lathyroides* did not respond to the igher dressings of superphosphate at 6 cwt./acre.

Tests using the winter legume, *Trifolium repens, T. ratense,* and *T. fragiferum* as the test plants again ave unsatisfactory results because of poor nodulation. ubsequent addition of a more effective strain by the se of soil inoculum gave marked improvement in noduation of white clover. Responses to superphosphate of even- and twelve-fold were recorded at low (2 cwt./cre) and high (6 cwt./acre) levels. Responses to alcium and to copper + zinc treatment were also ecorded in this soil. Red clover gave parallel responses o white clover, but the results from strawberry clover, hile similar, were less decisive because of the unsatisactory growth of this species under all the test onditions.

The relict lateritic red earth at the Strathpine Experient Station is deficient in phosphorus and calcium nd some responses to potassium and molybdenum have een obtained.

The foliar symptoms of *Paspalum scrobiculatum* and *haseolus lathyroides* are under study using water culures deficient in one or more elements. Both are aluable test plants in nutrient deficiency studies in the ub-tropical environment of south-eastern Queensland.

Rhizobium: Repeated failure of inoculation, espeially of the winter legumes used as test plants, has been xperienced. In the majority of instances this has been raced to the use of ineffective strains of the bacterium. This has now been overcome. In pot culture studies ith white clover that had failed to nodulate the addiion of calcium gave lower yields and, when satisfactory odulation was achieved, calcium gave the expected ield increments. Fairly satisfactory inoculation of the owpea group of legumes has been achieved, but there s some evidence that more effective strains within this roup must be developed.

(*d*) *Sown Pastures on Black Soils.*—(i) *Row Cultiated Pastures on* Paspalum scrobiculatum *and ucerne.*—Experiments at Lawes have shown the value f the grass *P. scrobiculatum* as a pasture plant for ubtropical regions, and in 1948 a large-scale grazing rial was designed to provide basic information on the arrying capacity and reaction to grazing of this species. The experiment includes four types of pasture, viz.: 1) *P. scrobiculatum* (alone); (2) *P. scrobiculatum* + ucerne; (3) lucerne (alone); and (4) *P. scrobiculatum* + the annual legume *Phaseolus lathyroides*. Each of hese pastures has been established as a sward and in rows at 42 and 63 in. spacing. All twelve treatments were separately fenced and they have been grazed by equal numbers of lambing ewes. This experiment was completed in June, 1953.

The main findings are—

(1) The best quality lambs have been produced on a pure lucerne diet, but the carrying capacity of lucerne pastures is appreciably below that of grass or grass-legume mixtures. On the other hand, the quality of feed on a pure stand of *P. scrobiculatum* (which will maintain adult dry sheep in good condition) is not sufficient to meet the requirements of lambs or lambing ewes.

(2) Both the quantity and quality of feed in mixed pastures of *P. scrobiculatum* and lucerne are satisfactory for lambing ewes and these pastures will carry approximately three ewes per acre, on a year-long basis.

(3) Mixed pastures of *P. scrobiculatum* and *Phaseolus lathyroides* have not been successful in this experiment, but from data now available it seems likely that such a mixture could be maintained under appropriate management. This would involve a short period of spelling during the summer growing season. The chief value of this annual legume would lie in its capacity to provide nitrogen for the grass; since the two plants *P. scrobiculatum* and lucerne (grown either as mixed pasture or as separate stands) would at all times provide adequate nutrition for the animals concerned.

(4) In lucerne pastures there is a real advantage from row cultivation which is expressed in terms of (*a*) a more even production during all months of the year, (*b*) better control of weed growth, (*c*) greater longevity, and (*d*) better production from effective rainfall, leading to slightly greater production (approximately 20 per cent. in rows at 42-in. spacing). It has been shown that production in all lucerne plots is directly related to the incidence of rainfall.

(5) In pastures of *P. scrobiculatum* there is, under hay conditions, a very marked increase in the yield from row cultivated plots, but under a uniform intensity of grazing the production from swards rises, over a period of approximately three years, to the same level. The data now available show that soil moisture is seldom, if at all, a limiting factor in a mature stand of this grass and that the growth of *P. scrobiculatum* is controlled mainly by temperature.

The two plants *P. scrobiculatum* and lucerne are obviously complementary, both in terms of production (i.e. period of growth) and in providing an overall balanced diet for stock. Some final experiments are now in progress to compare overall production from mixed pastures (incorporating both plants) and from separate stands of grass and lucerne where stock have free access to either component.

(ii) Paspalum scrobiculatum—*Frequency of Cutting.*—In a number of experiments with subtropical grasses it has been observed that close grazing or mowing—especially during the early part of the growing season—has adversely affected subsequent growth and vigour in the plants concerned. Since this is a matter of obvious importance in relation to pasture management, a number of experiments were carried out with *P. scrobiculatum* to determine the effect of different frequencies and heights of cutting on cumulative yields over one or more years.

The experiments have shown that (1) in general the cumulative yield for any one year is inversely proportional to the frequency of cutting; (2) this effect is progressively less marked where plants are cut at higher levels above ground; and (3) the yields in successive years are greatly depressed by frequent close cutting (e.g. mowing at a height of 1½ inches every 2, 4, 6, or 8 weeks). Over and above these results, however, it has been consistently recorded that the cumulative yield from plots cut at approximately 12-14 week intervals is less than that from similar plots cut at 10 or 16 week intervals.

In order to obtain some explanation of this result a new experiment was designed with many replicates of individual plants that were cut at 2, 4, 6, 8, 10, 12, 14, and 16 week intervals over a period of 18 months and thereafter rearranged to allow computation of growth curves from plants previously subjected to each of these treatments. This experiment has confirmed the previous results, and, in addition, it has shown that the yield of plants during the year following the several cutting treatments is similarly affected. A possible explanation of this somewhat unexpected result is that there may be a translocation of plant food reserves from the leaves to the roots, or basal tissue, at or about 12-14 weeks after the commencement of new growth. An estimate of root development was made on the basis of samples taken from 4-in. soil cores at fixed positions round each plant, but the position is complicated because any reduction in above ground growth, in itself, leads inevitably to lesser root growth. Samples of "roots" and "tops" are now being analysed in an attempt to follow the development and translocation of carbohydrates under each cutting treatment.

19. Nutrition of Plants in the Coonalpyn Downs, South Australia.

(Division of Biochemistry and General Nutrition.)

Unusually acute zinc deficiency has been found to occur in subterranean clover grown in one of the light, sandy soils in the Hundred of Archibald. Zinc sulphate was applied to this soil at seeding, at rates of nil, ⅛, 1¾, 3½, 7, and 14 lb./acre. Growth of subterranean clover (var. Bacchus Marsh) was found to be enhanced by the addition of as little as 1¾ lb. of $ZnSO_4.7H_2O$ per acre, and maximum yield was obtained by the application of 7 or 14 lb. of $ZnSO_4.7H_2O$ per acre. The numbers of plants present in the pasture and plots were not affected by the amount of zinc added, and yield per acre was governed by the mean weight per plant. An experiment was carried out in the same soil to determine the tolerance of subterranean clover to unusually large applications of zinc. The additions ranged between 14 and 126 lb. of $ZnSO_4.7H_2O$ per acre in increments of 28 lb./acre. The survival of plants and the yield per acre during the first year were reduced with each increase in the amount of zinc salt added above 14 lb./acre, but the mean yield per plant was not affected in those that survived. During the second year, the clover grew well on all of the plots, and no differences in density or yield were apparent. The concentration of zinc in the dry matter of leaf and petiole of these plants at the flowering stage during the second year was increased considerably by addition of the largest amount of zinc sulphate at seeding. The concentrations varied between 25.9 and 62.2 p.p.m. Zn.

The range of concentrations of zinc and copper in subterranean clover and lucerne grown in a number of soils of the Coonalpyn Downs has been investigated as an aid to the diagnosis of incipient deficiency of zinc and copper. Material for analysis has been collected as circumstances have permitted. The estimations have been carried out for the greater part on leaf and petiole of subterranean clover collected during the
flowering stage, and on whole tops of lucerne collect
during the same period of time. The minimum conce
trations found so far in subterranean clover (va
Bacchus Marsh) are 7.7 p.p.m. Zn and 1.9 p.p.m.
in the dry matter, representing extreme deficiency, a
the maximum concentrations found are 31.2 p.p.m.
and 5.0 p.p.m. Cu in the clover from areas fertiliz
with sufficient amounts of Zn and Cu salts for norm
development. The ranges of concentrations found so f
in lucerne are 5.3-26.5 p.p.m. Zn and 1.1-6.3 p.p.m.
in the dry matter of whole tops. Lucerne has be
found to grow well and to exhibit no apparent lesio
where zinc concentrations in the whole tops are as l
as 5.3 and 8 p.p.m. in the dry matter.

Satisfactory concentrations of zinc and copper ha
been found in mixed pasture that had been sown
Laffer sand nine years previously. No further applic
tion of zinc and copper had been made to this area sin
the original experimental dressing of 7 lb.
$ZnSO_4.7H_2O$ and 7 lb. of $CuSO_4.5H_2O$ was appli
at seeding in 1944. Leaf and petiole of subterrane
clover (var. Bacchus Marsh) at the flowering sta
contained 23.2 p.p.m. Zn and 6.9 p.p.m. Cu, and wh
tops of lucerne collected at the same time contain
26.3 p.p.m. Zn and 6.3 p.p.m. Cu in the dry matter.

During the late spring of 1952, subterranean clov
growing in light soil in experimental areas develop
symptoms which, in several respects, resembled th
which have been attributed to potassium deficien
Subsequent examinations revealed the occurrence
similar lesions in subterranean clover in a wide ran
of soils in the Coonalpyn Downs as well as in red-bro
earth near Adelaide. The potassium concentration
leaf and petiole of more than 50 samples of subt
ranean clover from affected areas and from apparent
healthy areas has been determined. In nearly all ca
the concentrations were found to exceed 1.5 per cent.
These should have been adequate for normal grow
Further work on this problem is proceeding. Duri
this preliminary examination, a concentration of or
0.47 per cent. K was found in the dry matter of le
and petiole of sparse and poorly grown subterrane
clover on the top of a low sand-rise. Samples collect
at 6-yd. intervals to the base of the slope, where t
clover was densely grown and vigorous, contained 0.
0.77, 0.67, 1.06 and 1.07 per cent. K respectively.
is probable that fertilization with potassium salts,
addition to the usual application of phosphate, zi
and copper, may aid the maintenance of plant cover
difficult terrain of that particular sort.

An effort is being made to induce uncomplicat
deficiency of the individual nutrient elements
subterranean clover and in strawberry clover gro
in nutrient cultures. The recognition of characteris
lesions should aid in field diagnosis of deficiencies
refractory soils.

20. Plant Toxicology and Chemical Weed Contr

(Division of Plant Industry.)

(*a*) *Evaluation of New Herbicides.*—Additio
information on the relation between structure a
activity has been obtained in the testing of new pot
tial herbicides synthesized by the New South Wa
University of Technology. One substance in sa
culture increased the growth of wheat but decreased t
growth of rape.

Preliminary studies of the herbicidal action
3-(*p*-chlorophenyl)-1,1-dimethyl urea (C.M.U.) ha
been completed. It was found that C.M.U. is a pow
ful herbicide acting principally through the r
systems of plants. There was evidence of upward mo
ment in the transpiration stream but none of dow
ward translocation from the leaves.

Green-house studies with maleic hydrazide indicated at this compound has growth-regulating properties. he possibilities of using maleic hydrazide to retard e growth of channel bank weeds during the irrigation ason is under investigation.

(*b*) *Mistletoe Investigations.*—Field trials in colla- oration with the Forestry and Timber Bureau have een continued. It has been shown the optimal dose injected 2,4-D can vary from year to year. Although is unlikely that 100 per cent. control may be effected single injections, it has been ascertained that in me coastal areas surviving mistletoes are likely to be lled by a beetle (*Bostrichidae*). Trials are being ade with new 2,4-D compounds which may show greater safety factor to the host plants.

(*c*) *Biochemistry of Cell Differentiation.*—Investi- ations have been initiated to ascertain the factors sponsible for the formation of new stem growth from ot tissues. The possibility of using anti-metabolites inhibit regrowth of weeds is being investigated.

(*d*) *Impedance Measurements.*—Further measure- ents on healthy and leaf-roll infected tubers are being ade at different stages of maturity. In immature bers there may or may not be a significant difference tween healthy and virus-infected batches, depending variety.

(*e*) *Soil Moisture Meter.*—A portable resistance- pacitance bridge, of novel design, has been made for e rapid measurement of soil moisture in the field.

(*f*) *Soil Sterilants.*—A range of soil sterilants is ing compared for the purpose of determining the ost effective compound for fire breaks around ectrical installations in the Australian Capital erritory.

(*g*) *Grass Weeds.*—Studies on the herbicidal action petroleum oil fractions have been completed and e results published in the *Australian Journal of gricultural Research.* Further work is in progress ith sodium trichloroacetate which has given good sults to date on Johnson grass (*Sorghum halepense*), uch grass (*Cynodon dactylon*) and paspalum *Paspalum dilatatum*).

(*h*) *Cumbungi* (Typha *spp.*).—Promising results ave been obtained with oil-based esters of 2,4-D and 4,5-T applied at the rate of 6-12 lb./acre.

(*i*) *Nut-grass* (Cyperus rotundus).—The use of dium trichloroacetate in controlling nut-grass is still nder investigation. Good control was achieved for period of nine months. The effect of a second pplication is being determined.

21. PASTURE INVESTIGATIONS AT KATHERINE AND KIMBERLEY.

(Land Research and Regional Survey Section.)

The Land Research and Regional Survey Section has ontinued its research on native and introduced pas- ures under dry land cultivation at the Katherine esearch Station, and under irrigation at the imberley Research Station. The work on these vestigations is recorded in Chapter XI., Section 3 seq.

IV. IRRIGATION.

1. GENERAL.

The Organization has two Irrigation Research tations, the Commonwealth Research Station Murray Irrigation Areas) at Merbein on the Murray iver in Victoria and the Irrigation Research Station Murrumbidgee Irrigation Areas) at Griffith, New outh Wales. Both are situated in the midst of impor- ant irrigation settlements and keep in close touch ith the settlers. The work of these two stations is ported in this Chapter.

Research into soils and their behaviour under irrigation has been carried out at both Merbein and Griffith in close co-operation with the Division of Soils (*see* Chapter II., Section 2).

Studies on irrigated pastures are carried out at Deniliquin, New South Wales (*see* Chapter III., Section 16), and other investigations of irrigation techniques for northern tropical areas are carried out by the Land Research and Regional Survey Section at the Kimberley Research Station near Wyndham, Western Australia (*see* Chapter XI., Section 3 (*b*)).

2. COMMONWEALTH RESEARCH STATION (MURRAY IRRIGATION AREAS), MERBEIN, VICTORIA.

The work of the Merbein Station extends over the middle and lower areas of the Murray River valley and is concerned largely with problems in soil conditions and plant growth associated with irrigation in a semi-arid environment. Both gravity and pumped irrigation distribution schemes serve the region.

Deterioration of land under irrigation is a world problem of great magnitude. Since its inception, the Merbein Station has devoted much of its activity to investigation of methods for arresting such diminution of productivity and for reclaiming land on which production has become uneconomic.

Among horticultural crops of the region, vines for dried fruit production are specially important. In agreement with the forecast made in May, 1952, from the Station's examination of dormant sultana buds, the 1952-53 season proved to be one of high fruitfulness for vines. The season was such that there was a high incidence of insect pests and fungus disease, including an unusually early and widespread occurrence of downy mildew. Drying conditions at harvest time were excellent and, in spite of all difficulties, a very big pack of dried vine fruits has been obtained.

Prominent among the problems of vegetable culture under irrigation is that of nematode infestation. In association with the Division of Plant Industry the Station has been engaged for some years on a programme of breeding of tomatoes resistant to nematode and other pests and diseases. The interest of the Station in nematology is being broadened considerably in view of the actual and potential importance of this subject in production of many of the crops grown in the region.

The work of the Station at Merbein on the processing of dried vine fruit has been included in Chapter XIII., Section 12.

(*a*) *Irrigation, Soil Preservation, and Reclamation.*—Each year there is an expansion of the use of spray irrigation in the Murray areas, especially for the production of vegetables and citrus fruits. An important aspect is the need, determined by soil types and topography, for extensive installations of spray irrigation equipment in the areas being developed for soldier settlement. Findings from the experimental work at Merbein are being applied in these and other areas. Considering fixed pipe-line systems, as distinct from portable systems, it has been found that for rotating spray heads of the types widely used in the region, 8.5 sprays/acre are capable of giving satisfactory water distribution under most weather conditions. Sprays of this kind spaced at 6.4/acre, as in many of the older installations, give adequate irrigation cover only in calm weather. While mature citrus trees, for example, may not show adverse effects from uneven water distribution, smaller plants such as young citrus and vegetables may suffer markedly.

A drilling rig constructed at the Station to assist in investigation of problems of waterlogging and soil salinity has been in use at Renmark throughout the year. These investigations are concerned largely with those parts of the Renmark settlement where the soils are formed mainly from material deposited under water. These soils are generally heavy, but all have sand at some depth underneath, sometimes as shallow as three feet from the surface, sometimes as deep as 50 feet. Soon after irrigation started in the Renmark area, troubles with high water-tables and soil salinity developed, and have appeared with varying severity throughout the settlement. Standard methods of tile drainage, found effective in remedying such difficulties in Mallee soils under irrigation, have proved unsatisfactory in the heavy soils at Renmark. For this reason, the Station has investigated the problem from the aspect of pumping water from the underlying waterlogged sands, with a view to relieving pressure of saline ground water within or close to the root zones of the crops.

A grid of piezometers put down with the aid of the drilling rig over a considerable area at Renmark has confirmed earlier indications that there is a continuous body of waterlogged material underlying the settlement. The problem is therefore a community one. Information has been obtained on the variability of the underlying sand strata, on fluctuations of water pressure levels throughout the irrigation season, on the direction of ground-water movement, on the effect of existing drainage installations such as large open drains, and on the locations of areas of highest groundwater levels where drainage is likely to be most needed and most effective.

Pumping from bores of 6-in. diameter put down to depths of the order of 80 feet into the deep-seated sand strata at Renmark has been shown to lower the pressure levels in the sands over a considerable area round each bore. Encouraging results have been obtained from a trial of "spear points" placed as a group at a comparatively shallow depth in the sand strata and linked to a common suction line. Such a system gives a much lower pumping lift than from the bores, and the ground water pumped away is of much lower salinity, representing a much smaller disposal problem. By the use of such a system, tile drains may be laid in sand freed from excess water in those Renmark soils which have sand, normally waterlogged, close to the surface.

(*b*) *Land Use.*—Soil surveys with particular reference to land use have been carried out by the Station in numerous small areas of the region in the past year. The major area under examination is one of about 600 acres at Colignan, recently developed for citrus and vegetable production under irrigation, mostly by sprays.

Renovation trials have now been in progress for four or five years on land at Woorinen previously abandoned for vine-growing under irrigation. The idea behind the trials is that growth of suitable irrigated forage crops on such land for some years might make it once again suitable for horticulture. One of these areas which has been under lucerne and pasture for four years will be planted to fruit trees this year. Another area was put under millet, then pasture, then lucerne. Lucerne establishment, which had been very poor on some of the more saline patches in this area, has improved considerably during the past season.

In the area served by the Wakool Land-Use Committee, studies by the Merbein Station are in progress with the object of examining the major soil changes after irrigation for a number of years of various pastures.

(*c*) *Horticulture.*—The very high potential fruitfulness of sultanas for the 1952-53 season, as indicated by the examination of sultana buds in May, 1952, was confirmed by detailed examination of vines in October, 1952. On the same vines records of the number of bunches per vine and the green weight of fruit w
taken at harvest time in 1953. A high correlation v
found between bunch number and green weight.

Time of bud burst of sultanas has been examined
detail on three properties in the Sunraysia distr
There was very little difference in average green wei
per bunch produced on shoots which burst on differ
dates. There was also very little difference in aver
bunch weight borne at each bud position along the ca
The shoots bearing fruit burst earlier and grew lon
than barren shoots, thus confirming earlier findings.

In the sultana cincturing trial this year the sing
cut cincture as well as the double-cut affected yield a
berry size, unlike last year when only the double
had any effect. Single-cut cincturing this year increa
berry size, though not as much as double-cut, wher
the single-cut caused the greater increase in fr
weight yield. The sugar content was equally depres
by both treatments.

The results are now available for the second yea
harvest from the sultana pruning trial in which
number of buds per vine is kept constant and
treatment consists of varying inversely the number
canes and length of canes per vine. While there w
no significant differences in yield in the first harv
the second harvest has shown a significant decrease
yield from the vines with the smallest number of ca
of the longest lengths. These particular vines w
pruned to five canes each carrying 25 buds.

From a further year's results with 2,4-D spray
instead of cincturing of currants, it seems clear t
spraying is superior to cincturing, at any rate
currants which have reached years of maturity. T
general situation has emerged that in the first year
spraying results may not be as good as with cincturi
but the sprayed vines consistently improve compa
with cinctured vines, and after several years may
much superior.

In attempts to find a way of improving the
fertility of some of the vine-growing lands of Woorin
two trials of gypsum and sulphur on vineyards
being carried out. After four years since the fi
dressings were put on, yield results are still inc
clusive, although vine health has improved notably.

Weed control by oil spray instead of by cultivat
has been tried for eighteen months on one of th
areas, and so far has not given a significant incre
in yield of sultanas.

At Koraleigh a trial of gypsum and "no culti
tion" on heavy lands has given only slight increases
yield of sultanas, not statistically significant. T
"no cultivation" trial on the Research Station its
suffered a difficult year, because of watering troub
and a spring infestation of apple moth.

Surveys of vine health in the Woorinen district ha
been continued. A limited experiment last Februa
showed that decreasing vigour of vines and their los
in yield closely followed increasing soil moisture stre
confirmation of this will be sought next season.

The assessment of the influence of soil pH on hea
of the vine in the Murray irrigation region may
carried out with increased precision if an allowance
be made for the effect of soluble salts on soil pH.
method of making such a correction for Woorinen so
has been worked out.

With reference to green manuring, it has been fou
that on Coomealla sandy loam annual application
phosphate is necessary for maximum growth of t
beans. This type of trial has now been extended
include a heavier soil.

Trial applications of the insecticides parathion and me-sulphur in the spring of 1952 for control of ealy bug on vines gave no significant results. As in e previous year, sultana bunches near the trellis osts had a greater percentage infestation than those way from posts, suggesting that the posts afford arbour for the insects during the winter.

Experiments on the control of "shoot restriction sease" of sultanas included an autumn application lime-sulphur last season. This was found to be effective, whereas a spring application just before d burst was almost completely successful in prevent- g the curled leaf and stunted shoot growth charac- ristic of the disease.

A point of considerable practical interest is whether e heavy incidence of downy mildew of the vine on rtain properties last season had any effect on the velopment of primordia for next season's crop. If ere were such an effect, it might influence the pruning the vines during this winter. Examination of rmant buds taken in June, 1953, from an area where e whole crop was badly infected with downy mildew November, 1952, showed that the percentage tential fruitfulness was not significantly different om that in the district as a whole. The average imordium size was appreciably greater than the strict average. In the area examined, downy mildew as so severe that by the end of November, 1952, all nches were destroyed and in some portions of the operty all leaves had dropped as well by that time. ood vegetative growth was made later in the season.

Weekly measurements of the circumference of alencia oranges were continued to the end of the 52 season. It has been established that regular easurement of a small number of oranges, the same es each time, is sufficient to give a good index of owth increments. This means that the measurements uld be made by growers themselves, to give indications variations in factors, notably soil moisture condi- ons, important in maintaining satisfactory growth.

Observations on blossoming and fruiting of citrus ave been continued. Records of the time of opening each flower and time of drop of flowers or young uit were kept as in 1951. In both Navels and alencias the past season was one of good setting. Most uit was set by relatively late-opening flowers on the cond, third, and fourth positions on multiple-flowered oots. There was an appreciable difference in time of ening between flowers on similar shoots on different des of the tree. From a better understanding of the ocesses of flowering and setting, a system of regula- on of these processes may be attainable.

(d) *Plant Nutrients.*—The Station's investigations this field continue to be directed largely towards trogen nutrition of the vine and soil conditions fecting it.

Soil analyses from the comprehensive fertilizer trial sultanas planted on soil of medium texture at the tation have confirmed previous findings that green anure over a period of years has significantly creased total soil nitrogen in the surface 6 inches 0 per cent. increase). A small increase, up to 10 r cent., is associated with the use of annual dressings sulphate of ammonia at the rate of 4 cwt./acre. oliage on the plots treated with sulphate of ammonia the rate of 4 cwt./acre shows greater content of tal nitrogen than that from plots not receiving this rtilizer. These results are from an area where yield creases of sultanas are commonly obtained by the se of nitrogenous fertilizer. This investigation is eing extended to include an area of lighter soil at Red liffs, where fertilizer trials over a number of years ave not shown any responses to sulphate of ammonia.

Trials of various rates of application of sulphate of ammonia to land carrying sultanas have been made during the past two seasons on Coomealla loam at the Station and on Murray sand on another Merbein property. In the Station trial, the total nitrogen content of foliage in October and December was increased by spring applications of sulphate of ammonia and decreased by growth of winter barley which was cut and removed at the end of August. In both trials, changes in soil nitrate during the season have been followed to gain information on nitrogen availability. Removal of nitrogen from the land by the barley treatment has been found very variable from plot to plot within each trial.

An experiment on different times of application of sulphate of ammonia at the same total rate of 3 cwt./acre has confirmed a previous finding that yield of sultanas is better when the fertilizer is applied in either early or late spring rather than as split dressings.

Further investigations on the accumulation of nitrogen in the sultana vine have been made over the period January to June. Leaf blades, petioles, shoots, trunk, and root have been sampled for analysis with the object of elucidating the question of winter storage of nitrogen in the vine.

(e) *Fruit Processing.*—This is reported in Chapter XIII., Section 12.

(f) *Vegetables.*—Results of investigation since 1950 of desirable characters in F$_1$ hybrid tomatoes for the glasshouse have been assembled for publication. The object of this work was to find whether the desirable characters of pairs of varieties could be combined together with F$_1$ hybrids. In two of these, S.A. Dwarf Red (C strain) x Vetomold and Tatinter x Vetomold, combinations of high yields, good growth habit, high percentages of first grade fruit, and resistance to leaf mould were obtained.

A trial of the use of "Krilium" for soil conditioning in the growth of tomatoes under glasshouse conditions has been started on Curlwaa loam at Buronga.

In work on field tomatoes, hybrids selected for resistance to fusarium wilt and for suitability to the conditions of the Murray Valley have reached an advanced stage. Several very promising lines in the F$_4$ generation are now under test for fusarium resistance in preparation for field plantings in 1953-54.

Selection for nematode resistance and suitable agronomic qualities of hybrid tomatoes obtained from crosses utilizing the resistant varieties obtained from the United States of America is being carried out each season. An increase in the percentage of resistant plants has been achieved. Although seed is sown in heavily infested seed beds and careful examination is made of seedlings before transplanting, many of those planted out develop root knots. Nevertheless, good progress has been made towards a useful resistant type.

A trial of the effects of methods of farm management on the root-knot nematode population of the soil, which was commenced at Red Cliffs in 1951-52, is still in progress. Soil samples are taken from the plots in spring and autumn and susceptible plants are grown in each sample. Where practicable, counts of nematode larvae on the roots of some of these plants are made while the plants are still young. Others are grown to maturity and given root ratings in accordance with the extent of gall formation. It has been found impracticable to make larval counts on plants grown in the soil samples taken in the spring, apparently because of low initial activity of the nematodes. The two fallow treatments, namely, a bare fallow and a summer fallow followed by winter barley, have shown some reduction in nematode population assessed by the above method. The treatment in which susceptible tomatoes are grown maintains nematode activity at a very high level. Owing to the difficulties in securing completely resistant tomatoes, the treatment involving growth of a resistant tomato crop has so far shown nematode activity of a somewhat similar order to that found in the treatment growing susceptible tomatoes.

During 1952, a small quantity of seed of *Crotalaria spectabilis* was obtained from the Division of Plant Industry. This plant has proved valuable as a cover crop in some parts of the United States of America, where it reduces the severity of nematode infestation. The seed has been sown at Red Cliffs in order to increase the supply of seed for use in further work on nematode control. Inoculation of the seed with a suitable culture supplied for the work by the Department of Agriculture was found necessary for optimum growth of this plant.

3. Irrigation Research Station (Murrumbidgee Irrigation Areas), Griffith, New South Wales.

Waterlogging and salinity are important problems in the Murrumbidgee Irrigation Areas, and much of the work of the Research Station at Griffith has been concerned with the principles and methods of applying water and the removal of surplus water by drainage. The district grows a particularly wide range of crops, the most important being citrus, peaches, wine grapes, vegetables, rice, and pastures. The early work of the Station was directed mainly at citrus problems, but in recent years studies of plant physiology and other more fundamental work have had a wider significance.

(*a*) *Irrigation.*—Studies are being continued on the effect of weather and soil moisture levels on transpiration. By following the soil moisture in a citrus orchard by progressive soil sampling, it has been found that the rate of removal of water from the soil progressively diminishes as the moisture content of the soil decreases. This information makes it possible to determine the best spacing of irrigation. Similar results are obtained when a representative sample of orchards in the district is taken. In this way, using evaporimeter readings, it is possible to construct soil moisture extraction curves during the winter (non-irrigation season) to predict when the irrigation season should open.

(*b*) *Drainage.*—The appropriate depth and spacing of tile drains for the major soil types on the Murrumbidgee Irrigation Areas has been determined and the results tabulated for use in the design of the tile drain systems. A method for determining the drainage characteristics of the land by the use of small bores has been evolved. This consists of sinking a small bore down into the water-table, pumping by means of a portable pump, and observing the extent of the lateral influence of the pumping on the water-table. These methods are now being used in a district-wide tile drain programme.

In long-term experiments the effects of two farm-size tile drain installations on the water-table, soil salt content, and health and productivity of plantings is being observed.

(*c*) *Soil Physics.*—The permeability of the soil is important in irrigation. The soil structure may be changed in such a way as to reduce its permeability by the use of unsuitable irrigation water or the accumulation of sodium salts in the soil, by mechanical compression due to faulty tillage practice, and by the loss of organic matter in the soil. Loss of soil structure leading to reduced permeability is a major problem of irrigation.

Changes in the microstructure of the soil have been studied. A technique was evolved which enables changes in the finer soil aggregates during permeation to be studied under the microscope. In this way t roles of displacement and solution of air and t swelling of soil aggregates on changes in permeabili during permeation have been resolved and the reaso for anomalous changes in permeability noted by oth workers have been explained. The effect of sodiu ions in the permeating solution, leading to a collapse the structural aggregates, was also investigated.

It was noted in an experimental orange orchard th where tillage is eliminated but weeds are suppress by the use of herbicidal sprays, water lies on the su face after very little has been applied as rain irrigation water. This does not occur on tilled plo It has been found that this is not due to changes the permeability of the undisturbed soil but to t storage capacity of the tilled surface layer of the so When this has been satisfied the infiltration rate tilled and bare untilled soil is the same. The perme bility of sod plots, however, is much greater and th has been traced to the formation in the soil of burro 2 mm. and more in diameter by insects and oth soil fauna. In this experiment soil aggregate stabili is reduced by tillage and increased by sod. It is al increased by the use of sulphate of ammonia as fertilizer, this being associated with a decrease in t soil pH.

(*d*) *Horticulture.*—(i) *Factorial Field Experime with Citrus.*—The investigation of the mangane deficiency that is found in this experiment was co pleted. It was found that, although the trees on t non-cultivated treatments were lower in mangane than those on the cultivated treatments, there was difference in the exchangeable soil manganese. It w also found that effects due to the fertilizer treatmen and that previously ascribed to irrigation could closely related to changes in soil pH induced by the treatments. All the experiment has now been spray with manganese and the visual deficiency sympto on the sprayed leaves have disappeared. The leng of time that this spray will be effective is now bei investigated.

The soil nitrogen studies have continued with further field sampling throughout the summer. Th has shown a slow rate of disappearance of exchangeab ammonia in the bare soil plots compared to the oth plots. The remarkably high content of exchangeab ammonia in the bare soil plots at the higher levels added nitrogen continues. These studies have al shown that the soil pH has been considerably lower by the increasing applications of ammonium sulpha fertilizer, and laboratory pot experiments have show that the capacity of the soil to nitrify ammonia h been considerably reduced.

(ii) *Frost Prevention.*—Trials continued with high-speed horizontal axis fan. Reasonably satisfacto control of air temperatures on frosty nights w obtained. However, it is felt that, to complete t tests, information on the prevention of frost dama to fruit is required. As no damaging frosts occurr during the 1952 winter it was not possible to obta this information (*see also* Chapter XXVII Section 5).

(*e*) *Plant Physiology.*—(i) *Soil Fertility.*—T methods of crop physiology have been used to invest gate the effects of adding organic matter, such rice hulls, to the soil. Three distinct types of respon have been recognized—a delaying effect on germinatio a set back to seedling growth, and a subsequent stim lation of growth such that the final yield exceeds th of the control. The stimulation is due to an increase intake of phosphorus, and it is upon this phenomeno that attention has been focussed during the curre year.

Further pot-culture experiments have strengthened e view that the additional phosphorus is liberated om the soil and is not derived from the added organic atter. In particular it seems that the addition of pure gars to the soil can produce the same effect as that oduced by rice hulls.

This work has shown that, by studying the physiology the crop plant as it grows in the field, it is possible learn something of the reasons why certain cultural actices and fertilizer treatments are beneficial. Such approach is sometimes more reliable than the more thodox study of the soil itself, and a combination these two methods is still more likely to give results.

(ii) *Plant Water Relations.*—The work is designed gain a knowledge of the factors involved in plant owth in response to water régime. The aim is to able a reasoned approach to irrigation practice and provide a better understanding of plant metabolism relation to water status.

The response of tomato plants and flax plants to a ief period of water shortage has been studied in der to understand how plants respond to differences soil moisture content. The relations for the whole ant and plant fractions have been considered for ovement of nutrients into and within the plant in lation to dry weight and moisture content changes. he studies have been most detailed with the tomato d have included trends for individual laminae and tioles in plants having eight leaves at time of eatment. The results point to a marked decrease in ptake of nitrogen and phosphorus during wilting and considerably enhanced intake very soon after water- g to field capacity. The protein nitrogen in the leaf ades followed the same pattern.

The findings show that water stress of even a oderate nature may have a measurable effect on plant unctioning. As such effects must influence ultimate ield the assessment of their nature is important irrigation practice.

(iii) *Leaf Area Measurement.*—A rapid method for e estimation of leaf area in crop plants was examined nd perfected some years ago. This method has now een tested for bias resulting from fatigue and other auses and has given satisfactory results. Experimental ork which could not otherwise have been done has een made possible by using this method.

V. ANIMAL HEALTH AND PRODUCTION.

1. General.

Research into problems of animal health and animal roduction has formed an important phase of the Orga- ization's activities. This work is undertaken within he Division of Animal Health and Production with ead-quarters in Melbourne, Victoria. The field of esearch undertaken by the Division has widened with he passage of time and has been modified to meet hanging national and scientific requirements. The ajor activities and the results obtained are reported n this Chapter and in Chapters VII. and VIII.

Attention has been drawn previously to the satis- actory advance in our knowledge and control of isease of livestock of Australia. Nevertheless, it is ecessary that this knowledge be advanced still further nd that the Division be maintained as the central ational organization for the attack on problems of isease whether these arise from internal or exotic auses. The increased security of the animal industry gainst livestock diseases has enabled the activities of he Division to be extended in the field of animal roduction. Chief among these extensions is the pro- ision to undertake the study of animal-breeding roblems associated with beef production in tropical Australia.

Co-operative work with other Divisions and with Departments of Agriculture and with the Universities in the several States and Federal Territories has continued to play an important part in the activities of the Division. During the year 47 original scientific papers were submitted for publication.

Section 12 of this Chapter sets out the investigations carried out by the Animal Genetics Section, other than those on sheep and cattle, which are included in Chapter VII., Section 14 and Chapter VIII., Section 8 respectively.

2. Animal Health Research Laboratory, Melbourne.

(Division of Animal Health and Production.)

The administrative head-quarters of the Division are situated in this laboratory where experimental work on microbiological chemistry and animal physiology and pathology is carried out. The results of the work relating to sheep are reported in Chapter VII. and those relating to cattle in Chapter VIII.

The following are the major investigations in progress at the Animal Health Research Laboratory, Melbourne:—Pleuropneumonia of cattle (*see* Chapter VIII., Section 2 (*a*)). Mastitis in dairy cattle (*see* Chapter VIII., Section 2 (*b*)). Haematuria vesicalis of cattle (*see* Chapter VIII., Section 2 (*d*)). Brucellosis of cattle (*see* Chapter VIII., Section 2 (*c*)). Physiology of milk secretion (*see* Chapter VIII., Section 6 (*b*)). Caseous lymphadenitis of sheep (*see* Chapter VII., Section 16 (*a*)). Toxicity of large rations of wheat (*see* Chapter VII., Section 9). Infertility and physiology of reproduction in sheep (*see* Chapter VII., Section 12). Sheath rot of wethers (*see* Chapter VII., Section 16 (*c*)). Footrot in sheep (*see* Chapter VII., Section 16 (*d*)). "Toxaemic jaundice" of sheep (*see* Chapter VII., Section 16 (*b*)).

3. McMaster Animal Health Laboratory, Sydney.

(Division of Animal Health and Production.)

Research at this laboratory includes studies on internal and external parasites, principally of the sheep (*see* Chapter VII., Sections 17-18), nutrition with particular reference to carbohydrate metabolism in ruminants (*see* Chapter VII., Sections 4 and 7) and to problems associated with drought-feeding of sheep (*see* Chapter VII., Section 8), on some aspects of the physiology of reproduction (*see* Chapter VII., Section 12), and on certain infections and metabolic diseases.

The McMaster Laboratory is, at present, the head-quarters for the work of the Section of Mathematical Statistics within the Division and several of the Section's officers are housed there. They have continued to play an active and most valuable part in the planning of experiments and in the analysis and interpretation of results. The officer in charge of this work is a member of several of the research teams, including those conducting the sheep-breeding trials and the Merino strain trials within the Division. The results of some of the work are incorporated in Chapter VII., Section 13 (*d*).

Other major investigations in progress at the McMaster Animal Health Laboratory, Sydney, are: Infectious bovine ophthalmia (*see* Chapter VIII., Section 2 (*e*)). Epididymites in rams (*see* Chapter VII., Section 16 (*e*)).

4. Veterinary Parasitology Laboratory, Yeerongpilly, Queensland.

(Division of Animal Health and Production.)

Research at this laboratory is concerned mainly with investigation of parasites and of parasitism affecting live-stock, particularly those occurring in Queensland. The laboratory also accommodates officers of the

Division of Entomology engaged on investigations into the control of the cattle tick, *Boophilus microplus* (*see* Chapter VIII., Section 4). During the year facilities for field work became available by the establishment of the Amberley Field Station, near Ipswich, where attention will be given to parasites of cattle.

Close co-operation with the Queensland Department of Agriculture and Stock in all research problems is maintained and is assisted by the Joint Veterinary Parasitology Committee.

Investigations in progress by the officers of the Division of Animal Health and Production include the following studies.

(*a*) *Liver Fluke.*—The snail intermediate host of the liver fluke, *Fasciola hepatica*, has been identified as *Simlimnea subaquatilis* in all the mainland States of Australia.

Under laboratory conditions and in a field trial the sodium and copper salts of pentachlorophenol showed considerable promise as molluscacides against *S. subaquatilis*, but the study of the residual effect on the snail population has not yet been completed.

(*b*) Haemonchus contortus *of Cattle and Sheep.*—Investigations to determine if *H. contortus* of cattle and sheep are distinct species have been continued and completed. It has been found that there are morphological differences in male and female parasites from cattle and sheep. Infective larvae from cattle strains are visually distinct from those from sheep. Evidence favours the decision that *H. contortus* of cattle and sheep probably comprises two distinct species.

(*c*) *Larval Tick Infestation of Horses.*—Lesions on horses similar to those found in allergic dermatitis ("Queensland itch") have been seen on numerous occasions scattered over the face, legs, and body. These lesions were accompanied by intense irritation. Microscopic examination of the lesions showed a typical allergic reaction. Intradermal skin tests gave a positive reaction with an antigen prepared from larval *Boophilus microplus*. The condition was also set up experimentally by the application of larval ticks of this species.

(*d*) *Tick Toxins.*—Studies on the toxins of ticks have been continued both by animal inoculation and by filter-paper electrophoresis. Electrophoresis studies showed differences in the protein composition of aqueous and saline extracts of eggs and larvae of *Boophilus microplus*. By complement fixation definite cross immunity reactions have been obtained. Immunization with extracts of *B. microplus* prevented death in rabbits inoculated with extracts of *Haemaphysalis bispinosa*. Positive complement fixation tests have been obtained with serum of rabbits immunized with *B. microplus* antigen when an antigen prepared from *H. bispinosa* was employed, as well as when the system was reversed. In a limited number of tests, immunization of rabbits with either *B. microplus* or *H. bispinosa* antigen did not affect engorgement of larvae of *H. bispinosa*. Microscopic examination showed that in immunized rabbits there was a more intense cellular reaction in the tissues than in non-immunized rabbits.

These studies are being continued with, in addition, other species of ticks, *Argas persicus*, *Rhipicephalus sanguineus*, *Ornithodorus gurneyi*, and *Ixodes holocyclus*.

(*e*) *Tick Taxonomy.*—A number of ticks were received for identification. The material examined included *Ixodes cordifer* Neumann collected in New Guinea and three specimens of *I. holocyclus* from Warragul, Warburton, and Mt. Buffalo, in Victoria. The distribution of *I. holocyclus* in Victoria had previously been considered as coastal, extending as far south as Lakes Entrance.

(*f*) *Allergic Dermatitis of the Horse.*—These studie have been completed. It was determined that allergi dermatitis was associated with the development of hypersensitivity to the bites of a sandfly, *Culicoide robertsi*, and could be prevented by regular weekl spraying with DDT. Treatment of affected horses wit "Hapamine" (histamine azoprotein) proved successfu in most instances.

Other major investigations in progress at the Veterinary Parasitology Laboratory, Yeerongpilly, are Epidemiology of parasitic gastro-enteritis of cattle (*se* Chapter VIII., Section 3 (*a*)). Faecal examinatio as a measure of helminth infestation in cattle (*se* Chapter VIII., Section 3 (*b*)). Amphistome of cattl (*see* Chapter VIII., Section 3 (*c*)). Worm nodule (*Onchocerea gibsoni*) in cattle (work awaiting the provision of an insectary). Protection against body strik (sheep blowfly) (*see* Chapter VII., Section 19).

5. F. D. McMASTER FIELD STATION, BADGERY'S CREEK NEW SOUTH WALES.

(Division of Animal Health and Production.)

The development and study of hybrid dairy cattl based on Zebu crosses with British breeds have bee continued. This study is reported in Chapter VIII. Section 6 (*a*).

Other investigations in progress are: Inbred flock of Australian Merinos (*see* Chapter VII., Sectio 13 (*a*)). Inheritance of component fleece character (*see* Chapter VII., Section 13 (*b*)). Hairiness o fluffy tip (*see* Chapter VII., Section 13 (*c*)).

6. SHEEP BIOLOGY LABORATORY, SYDNEY.

(Division of Animal Health and Production.)

It was decided some years ago to establish a laborator centre with adequate facilities for research on th physiology of the sheep and on wool production. A area of 115 acres at Prospect Hill, near Parramatta New South Wales, was acquired in August, 1946. Plan for the necessary buildings were prepared but because o the shortage of materials and labour these have bee considerably modified. Progress in the establishmen of the facilities has been extremely slow. A house t accommodate the farm overseer has been completed an occupied. During the year one of the large anima houses to accommodate sheep in pens was complete and was put to limited use. A temporary surgery ha been installed at one end, as well as an office which i occupied by one research officer, the farm overseer, an the head animal attendant. The fleece and shearing building has been completed. The feed store, garage and workshop, and a sheep shelter-shed are nearing completion. Two prefabricated laboratories have been erected and should soon be ready for occupation.

An earth dam on Prospect Creek, a dog-proof perimeter fence, and sheep yards have been completed. Also a start was made on the construction of sheep reception yards, sheep dip, fencing of the main drive, supply of water to troughs, and subdivision of the pasture area.

These facilities and those projected will constitute the Sheep Biology Laboratory which will form the centre for the basic physiological or biological study of the sheep within the Division and with which a liaison with studies carried out at the several field stations will be established. Research officers and staff that have been occupying temporary quarters in and around Sydney and Melbourne are gradually being brought together at this centre. A start has been made on the re-organization of the work.

During the year the work of the scattered staff has been carried out mainly at the Wool Biology Laboratory, the McMaster Laboratory, the Fleece Analysis

Laboratory, all in or around Sydney, and at the Animal Health Laboratory, Melbourne. The work of the group has included comparative studies of breeds of sheep, analysis of skin and fleece characters, experiments on skin autographs, population dynamics of hair follicles, hormonal regulation of wool growth, and the physiology of wool production. These studies ar reported in Chapter VII., Section 15.

Related studies which may not apply to the sheep directly are as follows:—

(*a*) *The Biology of Mammalian Melanophores.*—The pigment-producing melanophores have been studied in living tissue cultures of the skin of appropriate mouse embryos. The differentiation, movement, and pigment accumulation of melanophores and the transfer of pigment granules from melanophores to the epidermis and developing hairs have been studied.

(*b*) *Genetic Modification in Hair Follicle Development in the "Tabby" Mouse.*—A sex-linked gene *Ta*, recently discovered in the mouse by Falconer, produces tabby marking in the coat of female heterozygotes (*Ta/x*) and an apparently different set of modifications in female homozygotes (*Ta/Ta*) and male homozygotes (*Ta*). The modifications of "tabby" homozygotes and hemizygotes include absence of two or three types of pelage hair follicles and a reduction in the number of facial vibrissae. The investigation is being continued. It has important implications regarding the causes of follicle initiations and the origin of fibre type.

The work of the group has also included that of the Fleece Analysis Laboratory. During the year 29,639 measurements were made on fleece samples. These were required in the experimental biological work of the Division, mainly for the sheep-breeding and the Merino strain trial investigations. These determinations included those for yield, density, mean diameter, staple length, and crimp.

The investigations carried out in the Fleece Analysis Laboratory included that on the transfer of heat and moisture in fibrous masses, which has been continued.

A statistical analysis of the results of the preliminary experiments on "handle" of wool indicated that three factors influenced the "handle" of raw wool; these were fibre diameter, the percentage of suint, and the depth of the crimp waves. The experiments have been repeated but the results have yet to be submitted to statistical analysis.

An investigation was started on the origin of golden-coloured bands in wool from "Gilruth Plains". The association of the bands with the occurrence of rain after a dry spell seems to be well established. The investigation is being continued.

The examination of fleece samples from particular strains of Merino sheep showed that the correlation between crimp and fibre diameter within a strain was extremely low. This relation was found to hold true for the strains of sheep in three regional centres.

During the year instruments for measuring skin area, for measuring fleece temperature and for recording measurements of fibre diameter on a card were made and also a humidity cabinet with temperature and humidity control.

7. Regional Pastoral Laboratory, Armidale, New South Wales.

(Division of Animal Health and Production.)

Since the acquisition of "Chiswick" in September, 1947, much work has been done to define problems of the area and to extend or apply the findings of other research workers. "Chiswick" is one of the areas used for the study of strains of Merino sheep in several environments reported in Chapter VII., Section 13 (*e*).

The study of the effects of grazing management on pasture and animal production, which is a co-operative investigation with the Division of Plant Industry, has now been concluded and is reported in Chapter III., Section 15 (*c*) and Chapter VII., Section 21 (*b*).

Work on internal parasites of sheep has continued and has been supplemented by the appointment of an Ian McMaster Scholar to work on larval ecology. This work is reported in Chapter VII., Section 17.

A study of the management of stock and pastures with different proportions of sown and native pasture has commenced and is reported in Chapter VII., Section 21 (*c*).

Other investigations include the following:—

(*a*) *Studies on Animal Behaviour.*—Observations on the grazing behaviour in flocks and paddocks of different sizes were continued. The liveweight gains of flocks of two sheep were lower than in larger flocks and a study was made to determine whether the grazing behaviour was detrimental to liveweight increase in this flock. A paddock of 2 acres was screened off to observe any changed behaviour when sheep in adjacent paddocks were not visible.

(*b*) *"Staggers" in Sheep.*—During 1952, experiments were designed to confirm the protective role of cobalt both when given orally and when applied to a phalaris pasture as a top-dressing. Only one case of staggers developed and no conclusions could be drawn. In the winter of 1953, however, cases developed during May, earlier than usual, and after 4 weeks' grazing eight sheep of a group of 30 running on a phalaris-subterranean clover paddock have developed staggers. Cases have not occurred in 30 control sheep receiving cobalt per mouth nor in twenty sheep running in paddocks top-dressed with cobalt.

(*c*) *Production from Sown Pastures* versus *Native Pastures.*—The comparison of liveweights and wool production from two groups of Merino sheep of the same age and breeding, grazing sown and native pastures, has continued with the same sheep. The mean weights of the two groups in May, 1953, were 104 and 75.4 lb. for the sown and native pastures respectively. At shearing in November, 1952, the weights of greasy wool cut per head were 8.4 and 6.5 lb. As the group on the sown pasture were stocked at the rate of three sheep per acre the return on the sown pasture was 25.2 lb./acre compared with 6.5 lb./acre on the native pasture.

(*d*) *Studies of the Summer Management of Native Pastures.*—Sheep and cattle are being used separately and conjointly in a study being made by the Division of Plant Industry of the effect of various management practices designed to reduce the amount of aftermath at the end of the summer on the winter carrying capacity of the native pastures (*see* Chapter III., Section 15 (*c*)).

Further investigations in progress at the Regional Pastoral Laboratory, Armidale, are: Neo-natal mortality in lambs (*see* Chapter VII., Section 21 (*a*)). Internal parasites of cattle (*see* Chapter VIII., Section 3). Studies on anthelmintics (*see* Chapter VII., Section 17 (*a*)).

8. National Field Station, Gilruth Plains, Queensland.

(Division of Animal Health and Production.)

Pastures during the growing period of the wool clip shorn in March, 1953, have been fair to good at different times throughout the year, with the exception of a few weeks in January and early February when they became quite dry; mid-February rains, totalling 3.01 inches, brought about a good response, and the grasses on the grey and brown clay plains, namely, the Mitchell grasses (*Astrebla* spp.) and Queensland blue grass (*Dichanthium sericeum*), flowed successfully. A limited amount of Flinders grass (*Iseilema mitchelli*) germinated. A further 1.02 inches in mid-April prevented the grasses from drying off again completely in the abnormally high April temperatures, and 2.10 inches of rain in late April-early May has resulted in considerable germination of herbage, more on the heavy clays than on the red stony loams which carry mulga (*Acacia aneura*) as the dominant tree. The herbage growth was characterized by a heavy germination of wild mulberry (*Malvastrum spicatum*).

In general, sheep have been in good to fair condition throughout the year. Ewes of the strain trial were in excellent condition when brought in for mating in late April. Stocking rates continue to be conservative, the present rate over the whole station being less than one sheep to 6 acres.

The experimental investigations carried out during the year may be considered under two categories. Firstly, long-term Merino sheep-breeding studies and secondly, two smaller experiments which were almost completed within the year (*see* Chapter VII., Section 13 (*d*)).

Under the first category is included a selection trial in which different methods of selection are being compared and data are gathered for the determination of the heritability of certain characteristics of the Merino. Other trials in this category are the strain trial, in which five strains of the Australian Merino are being compared under the environments of Cunnamulla, Queensland, Armidale, New South Wales and Deniliquin, New South Wales, and a trial on the inheritance of hornedness and polledness in Merinos (*see* Chapter VII., Section 13 (*f*)).

Under the second category is included a preliminary trial to determine if wethers of the different strains of Merino represented in the strain trial vary in their efficiency of conversion of food (lucerne chaff and wheat) to clean wool. An experiment to determine the effect of testosterone propionate on the horn growth of young male Merinos (horned and polled) was also carried out.

Investigations into the causes of lamb mortality within approximately three days of birth have been continued in the experimental flocks. Of 711 lambs born in the selection trial, 9.6 per cent. died within three days of birth. The main causes were starvation and suffocation; in eighteen deaths out of 68 no factor contributing to death could be recognized.

The standardization of observers who take part in the sampling and measuring of sheep is now done annually, with the result that between-observer differences have been reduced and any that remain can be allowed for by making observer corrections to the field data.

Approximately 1,100 ewes have had numbered coloured plastic eartags inserted in their ears in addition to the aluminium tags already present. Each of the seven colours has been allotted to a group of ewes that needs quick field identification, especially during the drafting of flocks.

9. NATIONAL CATTLE BREEDING STATION, "BELMONT", ROCKHAMPTON, QUEENSLAND.

(Division of Animal Health and Production.)

"Belmont" was acquired by the Australian Meat Board in 1952 for co-operative cattle breeding investigations by the Organization and the Queensland Department of Agriculture and Stock.

Rainfall in Rockhampton for 81 years ending 1951 has a mean of 38.95 inches distributed with a marked summer peak, 24 inches falling in the summer months, December-March. The 1953 rainfall for the first six months, 19.35 inches is some 7 inches below the Rockhampton mean for this period.

(*a*) *Pastures.*—The response to the January, February and March rains, which totalled 17 inches, was very good on all formations and, although the Fitzroy River did not flood, the lower country produced a most luxuriant growth of a wide variety of useful grasses. Spear grass on the higher country provided good grazing until the first frosts were received in the middle of May when it browned off very rapidly. The present available pastures are ample in quality and amount for the numbers of stock being carried.

(*b*) *Stock.*—The numbers and types of cattle being acquired are in keeping with the experimental programme: 310 Hereford heifers were purchased late in 1952 and 306 were delivered to "Belmont" on 21st March; six Hereford bulls *ex* "Playfields", Dululu, arrived at "Belmont" on 6th March. One of these bulls has since died. Stock imported from the United States of America, consisting of three Zebu bulls, two Zebu heifers, and five Africander bulls, arrived at "Belmont" on 12th April after being quarantined in Sydney, and after being staged at Yeerongpilly, Queensland, for tick fever inoculations. Zebu-cross heifers and cows were acquired from "Waverley", St. Lawrence, and from "Roblyn", Pandoin, and 30 arrived at "Belmont" on 31st May. The experimental cattle population on "Belmont" at present is as follows:—

	Males.	Females.
Herefords	5	306
Zebus	5	2
Africanders	5	—
Zebu-cross	—	30
Total	13	338

Steps were taken to acquire the Shorthorn cattle necessary for the experimental programme, and three bulls with 180 heifers *ex* Coreena Pastoral Company properties, Claremont, Queensland, reached "Belmont" on 19th June. Advice has been received that the balance of the Africander consignment—two heifers—have arrived in Brisbane from the United States of America and are now undergoing quarantine. All stock, imported and local, is in good condition and, apart from tick worry which is discussed later, should continue to thrive well into the spring.

(*c*) *Improvements.*—The experimental programme calls for the creation of facilities which, in the early stages, will permit of the mating of at least twelve single-sire groups each of one bull and 30 cows in the first year, and in subsequent years paddocks each to contain one bull, 30 cows, and, at the time of mating, the three-months-old progeny of the previous year's joining.

(*d*) *Diseases and Pests.*—Outstanding in the environment is the cattle tick (*Boophilus microplus*) which is affecting all types and strains of cattle at present on "Belmont". There is little evidence so far that the Zebu and Africander strains are any less susceptible to infestation and worry than the Herefords. It has been necessary to dip or spray all stock once a month. The main plunge dip is charged with a BHC mixture, whereas once a month a "Rucide" (DDT) cream preparation has been used for spraying. Methods so far adopted to control tick infestation appear to be of limited value. Bathurst burr (*Xanthium spinosum*) and prickly pear (*Opuntia* spp.) are both serious weed pests on many parts of the property.

(*e*) *Experimental Programme.*—The first major undertaking will be a series of studies on the adaptation of representative groups of temperate and tropical strains of cattle to a tropical environment. The basic temperate region herds will consist of Hereford and Shorthorn males and females of pure strain in addition to crosses of both these representatives in both directions. Zebu and Africander bulls will be used as tropical region sires and these will be mated with females of both Hereford and Shorthorn breeds. Each sire group will be replicated three times. In all, this section of matings will involve twelve groups each consisting of one bull and 30 cows.

Observations and measurements will be made on a wide range of characteristics including birth weights, rate of growth, heat tolerance, skin texture, buffalo-fly and tick resistance. The first task will be to define these observations and to evolve techniques for the measurement and recording of selected characters. It is confidently expected that all facilities and stock will be ready for the first experimental mating in January, 1954.

It is planned to commence very soon a series of observations on the incidence of oestrus in cows.

10. POULTRY RESEARCH CENTRE, WERRIBEE, VICTORIA.

(Division of Animal Health and Production.)

The Poultry Research Centre, which was established in 1946 with the purchase of a foundation flock of 450 growing pullets, was built up to a satisfactory level during the year. Housing and equipment are now available to keep 3,000 pullets in individual hen-cages and 2,070 hens in houses fitted with trapnests or in single test pens. In addition, facilities have been provided to house about 600 roosters and to rear 6,000 growing chickens, required annually for replacement.

All post-mortem examinations are now carried out at the Centre with the object of obtaining complete and detailed mortality statistics. To facilitate the handling and computing of the numerous statistical data obtained yearly from over 5,000 fowls, the Hollerith system was introduced and the necessary punching and sorting equipment installed. The general research programme remained unaltered.

(*a*) *Investigation of Breeding Systems.*—Results from a detailed analysis of the F-pullets (F_4 generation) can be summarized as follows:—(i) The superiority of crossbred pullets in annual egg production has again been demonstrated for the fifth consecutive year. When crossbred pullets were compared with their purebred half-sisters they excelled by 39-46 eggs for the period ending at 72 weeks of age. (ii) No significant differences between the different types of crosses were found, though the single cross between White Leghorn male and Black Australorp female seems to be slightly superior to the reciprocal one. (iii) The rotational cross (criss-cross), probably carried out for the first time with poultry, gave excellent results in egg production and reproductive rate, and is the most economical of all crosses to be produced, as the female flock consists exclusively of crossbreds and only a few purebred males have to be purchased from outside. (iv) The group bred by selection of genetically superior sires and dams on the basis of progeny or sib-testing, or both, and mated together under a system which avoids close inbreeding, made further steady progress in egg production and is still superior to all other systems of purebreeding under observation. (v) The Hagedoorn system (superior sire method with half-sib matings) showed for the first time some effect of the selection practised. (vi) Inbreeding has now shown its deleterious effects on egg production, hatchability, and viability.

The conclusions, in general terms, from the viewpoint of practical breeding policy, can be summed up as follows: (i) The most effective way of improving characters of a quantative nature with low heritability in a pure-bred population is by selection of genetically superior parents which are discovered by progeny or sib-testing, or both, and by mating to avoid close inbreeding. (ii) Egg production, hatchability, and viability show heterosis as the result of heterozygosity and depression following increased homozygosity (inbreeding). (iii) Results obtained by purebreeding according to (i) can be further improved by obtaining heterosis through crossbreeding between breeds. Parents which produce superior purebred progeny proved also superior for crossbreeding (effect of general combining value). Evidence for nicking (specific combinability) has not been found yet.

(*b*) *Physiology of Reproduction and Inheritance of Fecundity.*—Work on the deep freezing of semen has been suspended until necessary equipment for this investigation can be made available. The storage of fowl semen at room temperature was investigated further with a view to improving fertility results by controlling bacterial growth through antibiotics. Sulphamerazine in Tyrode solution proved to be of no practical advantage in extending the storage time of fowl semen at room temperature over 4 hours. Experiments have been commenced with the object of labelling sperm with ^{32}P and tracing their passage up the oviduct to discover reasons for infertility in the female fowl. This promises to develop into a most valuable technique. Data regarding the quantity and quality of semen produced by a few hundred roosters will be analyzed for a study of the inheritance of fecundity in the male.

(*c*) *Other Investigations.*—Observations were made on the effect of different light intensities on egg production of pullets in individual hen-cages. The results have still to be analyzed. A series of experiments was undertaken to verify the possibility of interrupting incubation after 14 hours to permit a fertility test, and to continue incubation of fertile eggs after an interval of several days without harmful effects. This practice can be recommended if it is desired to obtain 100 per cent. fertile eggs.

11. MISCELLANEOUS INVESTIGATIONS.

(Division of Animal Health and Production.)

(*a*) *Sparganosis in Pigs.*—The investigation has been concluded and the findings are being prepared for publication.

(*b*) *Studies of the Copper Content of Blood and of Liver in Sheep and other Animals in Western Australia.*—Systematic studies of blood-copper levels and of copper concentration in the liver of sheep at Merredin, Western Australia, have been continued. An attempt has been made to correlate seasonal variation in the copper status of the sheep with changes in the inorganic constituents of the pasture. A co-operative study was started with the Western Australian Department of Agriculture at the Bramley Research Station. The copper status of the pasture plants is low and an attempt is being made to determine what other factors, if any, contribute to copper deficiency in the grazing sheep. Samples of blood and liver have been collected from marine and land animals in a comparative study of the copper content of tissues according to species and environment.

(*c*) *Silica Calculi in Wethers in Western Australia.*—A co-operative investigation was started on the occurrence of silica calculi in wethers in certain areas in Western Australia. The silica values in the urine of sheep in the affected areas, as elsewhere, were found to vary greatly, from 24 mg. to 320 mg. SiO_2/ml. The seasonal variation is being studied and a search is being made for the cause of the precipitation of silica compounds in the urinary tract.

(*d*) *Investigation of Beef Production in Australia.*—*See* Chapter VIII., Section 7.

12. ANIMAL GENETICS.

(Animal Genetics Section.)

The Animal Genetics Section was established during 1952 in co-operation with the University of Sydney. The unit is located in the Departments of Zoology and Veterinary Physiology and is under the leadership of Dr. J. M. Rendel. The Section aims to investigate the possibilities of applying genetical knowledge to animal breeding, and to introduce university honours students interested in genetics to the techniques and concepts of quantitative inheritance. During the year one honours student graduated from the Section and has joined the staff of the Poultry Research Centre, Werribee, Victoria. Two students are at present undergoing training in the Section.

The work of the Animal Genetics Section on sheep is described in Chapter VII., Section 14, that on cattle is described in Chapter VIII., Section 8. The remaining work of the Section is reviewed below.

(*a*) *Mouse Breeding.*—A mouse colony of some 1,000 breeding pairs has now been established. These are used in two different investigations; the majority in selection experiments designed to test empirically the effect of methods of selection, the rest in detailed developmental studies. In addition, some stocks of pure lines are kept. These have been split into sub-lines, so that at the end of ten generations or so, sub-lines derived in the first place from a single pair of inbred mice can be compared. This will give an approximate measure of the rate of origination of new genetic variation of a kind which cannot be attributed to single genes and so cannot be given a mutation rate in the normal way.

Three selection experiments are in hand and of these one has been going for three generations and already shows response to selection. This experiment is being carried out in collaboration with the Veterinary Physiology Department of the University of Sydney and is designed to create a line of mice sensitive to oestrogen and a line insensitive to it. It will yield lines of mice which should be of use in two ways (i) in studying the genetics of cancer susceptibility in mice, (ii) in further studies of the Naked gene, which are described below.

More detailed studies will later be carried out on stocks of mice which have been imported from Britain. Stocks of these mice are being built up; in the meanwhile one, known as Naked, has started to yield interesting information. The Naked mouse has hair which breaks off close to the skin very soon after the fibre is fully formed. This mouse has hair only on skin in which fibres are actively growing, and so the way in which waves of growth pass down the body from head to tail can be followed. The characteristic patterns and rates of hair growth have now been established for these mice. Normally, waves of growth pass from head to tail. The picture is the same for males and females, and for castrated and ovariectomized mice except that ovariectomized mice seem to have a slightly faster growth than entire females. In pregnancy all growth ceases and the mouse becomes completely naked a few days after parturition. There are several features of the resumption of hair growth which offer a lead to further study. There is a strong suggestion that growth patterns are affected directly or indirectly by level of oestrogen. When the stocks are established this gene can be transferred into lines of high and low oestrogen sensitivity and the effect of this sensitivity on hair growth observed.

(*b*) *Production of Antibodies and Disease Resistance.*—Dr. Sobey arrived from Edinburgh this year to undertake research in this field. The subject will be closely connected with work on myxomatosis in the first instance. Some general observations on the variability of response of pure lines of mice to injection of antigens are under way, and steps have been taken to start a rabbit colony for the work on myxomatosis.

(*c*) *Genes and Chromosomes.*—In recent years two schools of thought about the nature of the gene have arisen. One supposes that the gene is a large complex structure capable of acting as a multiple antigen and of taking many forms which are familiar to us as series of multiple alleles. The other supposes that there is confusion here between single genes and blocks of closely linked genes. Most, if not all, series of multiple alleles would be closely linked genes. To test this mutations could be looked for at a locus which has several alleles and see whether mutation was associated more frequently than expected with chromosome interchange. If it is, this would suggest that a proportion of the new types apparently due to mutation were in fact due to interchange between groups of closely linked genes which only very rarely cross over. Stocks of *Drosophila melanogaster* for such experiments have now been made, and the first experiments set up. This experiment will have to run some time before sufficient mutations have accumulated.

The actual process of chromosome interchange remains obscure. No explanation so far put forward accounts satisfactorily for the simultaneous breaking of two chromatids at the identical place. The effect of temperature on the rate of interchange as reported in the literature suggests inconsistency with current theory. The data are inadequate for positive proof. Stocks of *Drosophila* are in the making which will enable this to be put to the test.

VI. NUTRITION.

1. GENERAL.

A knowledge of animal nutrition is of fundamental importance to the efficient conduct of Australia's pastoral industries. The Organization's work in this field has been largely confined to studies of the nutritional physiology of the sheep and the influence of nutrition on wool production. This work is centred at the Division of Biochemistry and General Nutrition. Application of the results of this work to the practical problems of the sheep industry continues to yield economic dividends which in recent years have been most spectacular. Initially there was the demonstration that areas in southern Australia, hitherto abandoned as useless for agriculture, can be transformed for efficient production when trace element deficiencies of zinc and copper have been rectified. As a corollary to this discovery, and by virtue of the complementary work on pasture improvement carried out by the Division of Plant Industry (*see* Chapter III.), it is now clear that vast areas of the Australian continent, particularly in low rainfall regions, can similarly be rendered more productive after trace element adjustments have been effected. The results of these experiments have indicated the way for developments of great economic significance, and the knowledge obtained from many other researches in the field of nutrition is finding its way steadily into practice.

Division of Biochemistry and General Nutrition.—The head-quarters and laboratories of the Division are in the grounds of the University of Adelaide, and it has field stations at various sites in Australia where nutritional disabilities occur. The Division's work is largely devoted to the nutritional physiology of ruminants, more especially to the nutrition of sheep and to the influence of nutrition on wool production. Knowledge arising from the Division's experimental work is extended to application by the State Departments of Agriculture with which there is close liaison. Close co-operation has also continued between the Division and the University of Adelaide. The Division's central field station, "Glenthorne", is now rapidly developing into a fine tool for research, considerable progress having now been made there with subdivision, pasture establishment, and the accumulation of Merino flocks. This Chapter describes some of the main researches of the Division, and lists others which are treated in more detail in Chapter III., Sections 11 and 19, and Chapter VII., Sections 2, 3, 5, 6, 10 and 11.

2. NUTRITION AND WOOL PRODUCTION.

(Division of Biochemistry and General Nutrition.)

During the year a review of existing knowledge of wool growth was prepared, by invitation, for an authoritative text on the physiology of farm animals which is being published in England. Experimental studies of nutritional factors which directly influence wool production are reported in Chapter VII., Section 2.

3. STUDIES OF THE METABOLIC PROCESSES OF SHEEP.

(Division of Biochemistry and General Nutrition.)

A series of studies which aims at more complete understanding of the physiological and biochemical processes by which the sheep deals with its fodder has been continued. These investigations, together with others in this field carried out by the Division of Animal Health and Production, are described in Chapter VII., Sections 2-11.

4. ENERGY METABOLISM.

(Division of Biochemistry and General Nutrition.)

The indirect calorimeters which render possible a close assessment of the amount of energy dissipated by the sheep have been in almost constant use during the past year to provide information essential for the understanding of the overall problem of nutrition and wool growth (*see* Chapter VII., Section 5). During this period a small and novel calorimeter has been built for the study of energy transactions in rats and other small laboratory animals. The primary purpose of this study is to help with the understanding of the metabolic lesions that occur in zinc deficiency.

5. VITAMIN A REQUIREMENTS OF THE SHEEP.

(Division of Biochemistry and General Nutrition.)

The series of studies of the vitamin A requirements of the sheep has now been completed. The information gained from these investigations has been published, and provides a sound basis of knowledge of this aspect of animal nutrition.

6. EFFECTS OF CHRONIC FLUOROSIS.

(Division of Biochemistry and General Nutrition.)

The studies of disabilities imposed on sheep confined to waters containing an abnormally high concentration of fluorides have been continued (*see* Chapter VII., Section 10).

7. MINOR ELEMENT DEFICIENCIES IN ANIMALS AND PLANTS.

(Division of Biochemistry and General Nutrition.)

The underlying reasons for the more intensive studies of the deficiency states which supervene in plants and animals when the minute quantities of copper, zinc, &c., necessary for normal function are not provided, have been discussed in previous Reports. These studies cover a wide field of knowledge extending from nutritional physiology to tissue metabolism; and all seek a more complete understanding of the functions served by these essential traces of heavy metals in living tissues. A series of studies of copper and cobalt deficiencies in the sheep is referred to in Chapter VII., Section 11. This is a continuation of the first series which led to important agricultural developments and to the simple practical means of dealing with serious ailments which affect sheep depastured in many areas in Australia and elsewhere.

(*a*) *Copper Deficiency in Rats and the Effects of Molybdenum on Copper Metabolism.*—A second series of nutritional and biochemical studies of the inter-relationships between molybdenum and copper has been undertaken to extend further the findings of the studies mentioned in previous Reports. More detailed attention is now being given to metabolic lesions incurred in copper deficiency and to the physiological processes involved in the absorption, storage and elimination of copper. These have a direct bearing on the control of copper deficiency.

(*b*) *Zinc Deficiency in Rats.*—The solution of the difficult technical task involved in the freeing of foodstuffs from zinc has rendered possible a comprehensive physiological study of the zinc-deficient animal, and has opened the way to the investigation of the function that zinc assumes in living tissues. These exacting studies have been considerably extended. A close study has been made of the zinc-deficient rat's carboyhdrate metabolism, fat storage, and nitrogen metabolism, and the overall energy transactions are being studied to throw further light on the findings. The metabolic lesion incurred by zinc deficiency is revealed only with difficulty as the zinc-deficient animal grows only to the limit allowed by its zinc intake; and once zinc becomes a functional part of the tissues it is retained with extraordinary tenacity.

(*c*) *Metabolic Defects in Zinc Deficiency.*—A study has been made of the aldolase content of the muscles of zinc-deficient rats, and the rate of anaerobic glycolysis of the diaphragm muscles has been investigated. A detailed study of the phosphorylated hexoses and trioses in the muscles of zinc-deficient rats was also made during this period.

8. VITAMIN B_{12}.

(Division of Biochemistry and General Nutrition.)

(*a*) *General.*—Experiments in the laboratory and in the field have proved that the untoward effects of cobalt deficiency in ruminants are those which supervene on a deficiency of the cobalt-containing accessory food factor, vitamin B_{12}; and have shown that it is unlikely that cobalt serves any essential physiological function other than as a constituent of the complex molecule of vitamin B_{12} which originates in nature only as a product of the metabolism of certain micro-organisms. These facts have opened up new and important investigations which bear directly on the outstanding problems encountered in the nutrition of animals other than ruminants.

(*b*) *Microbiological Estimation of Vitamin B_{12}.*—Studies of the relations between the cobalt-content of the ingesta and bacterial synthesis of vitamin B_{12} have thrown up into high relief the complications which vitamin B_{12}-like substances introduce into microbiological assays. The synthesis of vitamin B_{12} and of pseudo-vitamins B_{12} under different conditions has been investigated in the rumen contents of a number of sheep confined in metabolism cages in the Hackney annex; and the findings are an important part of the intensive studies of cobalt deficiency in the sheep which are being conducted there.

(*c*) *Vitamin B_{12} Requirements of the Rat and Vitamin B_{12} Assays.*—The use of the rat as an experimental animal for the estimation of vitamin B_{12} has now been rendered possible; the success of the method depends on the lowering of the vitamin B_{12} reserves in the mothers of the rats used for the assays. Vitamin B_{12}-free rations capable of sustaining normal growth when supplemented with vitamin B_{12} have been evolved, and a number of studies of the metabolic breakdown which supervenes on a deficiency of this vitamin has been started.

(*d*) *Vitamin B_{12} and Haemopoiesis.* — The mechanism through which vitamin B_{12} influences the formation of protoporphyrin is being studied as a part of a more comprehensive investigation of the function of vitamin B_{12} in the production of blood cells. A long series of estimations of the free protoporphyrin and coproporphyrin in the erythrocytes of sheep which had been reduced to the final stages of vitamin B_{12} deficiency, and of the changes in the concentrations of these porphyrins has been determined during the period of restoration to normal health subsequent to treatment with vitamin B_{12}. The free protoporphyrin in the red cells of cobalt-deficient sheep is invariably higher than normal, and the concentration falls to normal after treatment of the animal with vitamin B_{12} or with cobalt. The concentration of iron in the plasma of the cobalt-deficient sheep is either normal or high. Free protoporphyrin in the red cells of copper-deficient sheep has been found, similarly, to be high, though the concentration of iron in the plasma is lower than normal.

9. PLANT NUTRITION.

(Division of Biochemistry and General Nutrition.)

The studies on mineral nutrition of plants, especially of the plants' requirements of zinc and copper, have been continued. This work is described in Chapter III., Section 9.

10. FIELD STATIONS.

(Division of Biochemistry and General Nutrition.)

At the Division's central field station, "Glenthorne", situated about 11 miles south of the main laboratories, considerable progress has been made with subdivision fencing and with the establishment of pastures. Tenders have been let for the erection of a field laboratory and fodder processing room to serve the sheep pens that are used for semi-intensive nutritional investigations. The main flock now has about 1,000 strong-woolled Merino sheep in it, and there is also a small flock of fine-woolled Merinos retained for special experimental work.

During the year the usefulness of whale solubles, a by-product of the whaling industry, as a protein supplement in the rations of pigs was estimated by two experimental trials which were undertaken as a co-operative effort at the request of the South Australian Department of Agriculture. The results are now being prepared for publication. The trials provided an opportunity for officers of this Division to become familiar with the pig as an experimental animal and, at the same time, to answer questions of considerable immediate practical importance to animal industry. Nutritional experiments with a very considerable outlay on a pig-breeding establishment would be necessary before numbers suitable for critical scientific experiments would be available, and so a decision was reached to utilize pigs only for special experimental work for which other animals are unsuitable.

VII. SHEEP.

1. GENERAL.

Wool is of the utmost importance in the Australian economy. Not only does it provide our major export, but it allows the use of vast areas of marginal land which cannot be turned to good account in other ways. With a sheep population of over 115,000,000, Australia produces about one-quarter of the world's wool and about twice as much as any other country, and more than one-half of the world's production of fine wool. Thus Australia has a vital interest in ensuring that wool can withstand the competition from artificial fibres. The remarkable success of the latter has been due in the main to the clear understanding arising from research on the physical and chemical properties of the new fibres. Moreover, the chemical industry established to produce them is planned as a co-ordinated and organized unit which ensures maximum efficiency and minimum wastage at all stages.

It is a major aim of the Organization's integrated programme of research in aid of the wool industry to investigate every phase of sheep and wool production: soil, pastures and nutrition, genetics, animal husbandry, wool processing, textile manufacture, and the exploitation of by-products. The Organization has been given responsibility for carrying out this extensive programme under the provisions of the *Wool Use Promotion Act* 1945. The Government has set aside funds earmarked for this purpose amounting to almost £350,000 per annum in a Wool Research Trust Account.

Soil fertility is obviously of prime importance and outstanding results have been achieved in combating soil infertility arising from minor element deficiencies. On the plant side, too, special emphasis has been placed on pasture improvement and weed control. The work of the Organization on soils, pastures, and related matters affecting the pastoral industry is carried out by the Division of Soils and the Division of Plant Industry (*see* Chapters II. and III.).

Work on the sheep itself has been undertaken within the Division of Animal Health and Production (Chapter V.) and the Division of Biochemistry and General Nutrition (Chapter VI.), the Section of Mathematical Statistics being closely associated with the breeding investigations (*see* Section 13 (*d*) below), and the Division of Entomology co-operating in the field of animal disease (*see* Section 20 below).

The Organization's work in the investigation of wool processing and wool textile research is undertaken at the Wool Textile Research Laboratories and the Division of Industrial Chemistry (*see* Chapter XVI.). The Animal Genetics Section's work on sheep breeding is described in Section 14 below.

2. NUTRITION AND WOOL PRODUCTION.

(Division of Biochemistry and General Nutrition.)

The series of experiments relating directly to nutrition and wool production has now been extended to provide further knowledge of the metabolism and utilization of the sulphur-containing amino acid, methionine, which is convertible *in vivo* to cystine, the main amino acid in wool keratin. Studies of the physiology of the wool follicles have been initiated to extend existing knowledge of the process of keratinization. In these studies the metabolic lesion, which previous work had shown to occur in the wool follicles of copper-deficient sheep, is being investigated further. Another series of experiments just completed has shown that both the rate of wool production and the efficiency of the conversion of the proteins in the fodder to wool keratin depend essentially on the overall energy transactions of the sheep, and has established fundamental laws which govern wool production.

3. PROCESSES OF RUMINATION.

(Division of Biochemistry and General Nutrition.)

Studies of the physiological and microbiological processes of rumination have been continued, and an investigation of the amino acid constitution of the bacterial and protozoal fraction of the rumen contents has been started as a preliminary to a more extensive study of the overall changes which occur in the fodder proteins during their passage through the rumen.

(*a*) *The Passage of Starch from the Rumen to the Abomasum.*—The greater part of the starch in the stomach of the sheep is present in the fluid portion of the contents; the small amount in the solids is probably lodged in bacteria attached to the plant residues. A very large part of the starch of the whole digesta may be carried in the ciliate protozoa of the rumen fluid. Starch/lignin ratios in the stomach contents suggest that there is an extensive destruction of starch in the omasum, and this is strongly supported by the lowered concentration of both starch and protozoa in the omasal fluid. The amount of starch reaching the abomasum is nutritionally insignificant even when the fodder contains large amounts (up to 150 g. starch/day).

(*b*) *Functions of the Omasum.*—Starch/lignin ratios and nitrogen/lignin ratios in the various compartments of the stomachs of slaughtered sheep indicate that only very small amounts of reticular contents may pass directly to the abomasum via the omasal groove and that little if any liquid is squeezed away mechanically from the solids in the omasum. The amount of water calculated to be absorbed from the digesta entering the omasum ranged from 33 to 64 per cent. and the amount of fatty acid from 40 to 69 per cent. in seven sheep slaughtered for these estimations.

(*c*) *The Conversion of Plant Nitrogen to Microbial Nitrogen in the Rumen.*—The distribution of nitrogen and lignin in the rumen contents and fodder of slaughtered sheep has shown that approximately half of the plant nitrogen fed to these animals in a diet of wheaten hay chaff was converted to microbial nitrogen in the rumen.

(*d*) *The Fermentation of Hemicellulose by Washed Suspensions of Rumen Bacteria.*—Studies of the fermentation of hemicellulose (prepared from wheaten hay) by washed suspensions of rumen bacteria have been started. At present the results indicate that the proportions of acetic, propionic, and butyric acids formed under these conditions are similar to those produced in growing cultures of the rumen organisms.

(*e*) *Utilization of Urea.*—The experimental trials to test the usefulness of supplements comprised of various mixtures of urea and starch (grain) as protein concentrates for sheep under natural grazing conditions which were undertaken as a co-operative project with the Queensland Department of Agriculture and Stock at their Toorak Field Station, Julia Creek, north-west Queensland, have been continued. Serious disabilities in the rations were revealed in the first trial and a second was abandoned after six weeks when, subsequent to the rapid growth of pasture which followed heavy rains, the experimental flocks refused to consume the concentrated rations. Another experiment has been started with the onset of dry feeding conditions at Toorak, and a similar, pilot-scale experiment with similar supplements fed to sheep confined in pens at Glenthorne.

4. EFFECTS OF DIET ON RUMINAL DIGESTION.

(Division of Animal Health and Production.)

Digestion experiments were continued at the McMaster Animal Health Laboratory, Sydney, in collaboration with the School of Agriculture, University of Sydney. Statistical analyses of the data obtained showed that the pH in the rumen of sheep fed on diets containing more than 50 per cent. of concentrates is about 0.3 less at any level of volatile fatty acids than when the diet is comprised of roughage.

5. ENERGY METABOLISM.

(Division of Biochemistry and General Nutrition.)

Experiments on the energy transactions in the sheep have been continued and have been directed mainly to studies of nutrition and wool growth. This series has not yet been completed.

6. CARBOHYDRATE METABOLISM.

(Division of Biochemistry and General Nutrition.)

(*a*) *Insulin Hypoglycaemia in Ruminants.*—The effects of insulin on sheep and lambs have been studied further, and extended to an analysis of the different responses which supervene according to the route of injection. The previous findings that adult sheep do not convulse after intravenous injection of massive doses of insulin, even though the sugar in the blood is reduced to negligible amounts for long periods, were confirmed. After the sympathetic nerve supply to the adrenal glands is abolished by severing the splanchnic nerves, adult sheep were found to be more sensitive to insulin: they then convulsed after the intravenous injection of small quantities of insulin.

Subcutaneous injections of insulin into adult sheep bring about a markedly different response; relatively small doses are followed by long periods of hypoglycaemia and severe convulsions which frequently do not respond to glucose therapy notwithstanding the re-establishment of a normal blood-sugar level. Young lambs are much more resistant to intravenous injection of insulin, and behave like non-ruminant animals.

(*b*) *Perfusion Experiments.*—An apparatus has been designed and built for the study of isolated organs under physiological conditions. This will be used for the investigation of certain aspects of carbohydrate and fatty acid metabolism of the sheep using livers isolated from nervous and hormonal influences.

(*c*) *Intermediary Carbohydrate Metabolism.*—The levels of pyruvate in the blood of normal sheep and lambs during glucose tolerance tests have been studied. The observed fact that pyruvate concentration rises after ingestion of sodium propionate but not after ingestion of glucose is another indication of differences in the channels through which fatty acids and sugars are metabolized. The lead is being followed. Sheep in which a state of diabetes has been induced by alloxan injections are being used in the study of the utilization of carbohydrate by ruminants.

7. CARBOHYDRATE METABOLISM IN PREGNANCY.

(Division of Animal Health and Production.)

This work is undertaken at the McMaster Animal Health Laboratory, Sydney. During the past year further experimental evidence has been obtained to indicate the occurrence of a breakdown in the Krebs tricarboxylic acid cycle when pregnant ewes are fasted. In these ewes, blood glucose is usually low, whereas levels of acetoacetic acid, β-hydroxybutyric acid, lower fatty acids, and citric acid are high. Utilization of glucose by the peripheral tissues of fasted pregnant ewes is considerably greater than in fasted non-pregnant ewes. Even when blood-ketone levels are high, they are not utilized but some experiments strongly suggested the output of ketone bodies by peripheral tissues. The blood picture of pregnant ewes which showed clinical signs indistinguishable from those of pregnancy toxaemia was not consistently different from that of fasted pregnant ewes which were clinically normal, but there has not, as yet, been an opportunity to follow cases of pregnancy toxaemia from the onset to the terminal stages.

All the evidence so far is compatible with the occurrence of a metabolic block in the normal oxidative pathways of carbohydrate and fat within the tissues when pregnant ewes are fasted. The very high levels of citric acid in the blood indicate that the block occurs in the citric acid → α-ketoglutaric acid stage of the cycle. Experiments involving the injection of intermediary metabolites of the Krebs cycle, and of malonic acid, a specific inhibitor of succinic dehydrogenase, have shown conclusively that this cycle does operate in the sheep. In some of the experiments in which pregnant ewes were fasted, signs were observed which were clinically indistinguishable from those commonly seen in the initial stages of pregnancy toxaemia in the field, but the later stages of persistent drowsiness, terminated by death in coma, did not occur. The significance of these findings in relation to the aetiology of pregnancy toxaemia of ewes is still uncertain and the work will be continued.

8. Drought-feeding and Related Problems.

(Division of Animal Health and Production.)

This work is undertaken by the McMaster Animal Health Laboratory, Sydney. Experiments at Glenfield, New South Wales, on drought feeding of sheep have been continued in collaboration with the New South Wales Department of Agriculture and with further substantial support by the New South Wales Graziers' Association from the Burdekin Bequest. Principal results of the year's work may be summarized as follows.

(i) Weaners which had been fed on drought rations comprised wholly of wheat, or of a 50:50 mixture of wheaten chaff and wheat, showed no difference in their ability to grow and thrive when fed generously thereafter.

(ii) When two groups of weaners, one of which had been fed for eight months on a drought ration of 50:50 wheaten chaff and wheat, and the other on the same ration *ad lib.* were turned out on pasture, the former group gained in weight while the latter actually lost weight. The pasture used was of poor quality.

(iii) The addition of salt (sodium chloride) to drought rations comprised of wheaten chaff and wheat increased the rate of food consumption. This might well be a disadvantage under drought conditions. In a recent trial two groups of weaners were fed *ad lib.* on 10:90 wheaten chaff and wheat, and a supplement of agricultural salt was supplied to one group. The groups showed no significant difference, under these conditions, in total food consumption rate of food intake, and liveweight increase.

(iv) When ground limestone was used as a calcium supplement for weaners which were fed *ad lib.* on cereal rations, weight gains were significantly better than when the additional calcium was supplied as slaked lime.

(v) Poor quality roughage or straw is frequently available under drought conditions and an attempt was therefore made to determine whether adult wethers could be maintained on cereal straw of very low protein content (1.2 per cent. crude protein) if supplemented in various ways which would enhance its food value or palatability. The straw was supplied *ad lib.* and the supplements used were: 1.5 per cent. urea, 5.0 per cent. molasses, 1.5 per cent. urea plus 5.0 per cent. molasses, 3 oz. wheat per head, 1.5 per cent. urea plus 3 oz. wheat per head, 3 oz. meat meal per head, a lick comprised of 2 parts salt: 1 part lime *ad lib.*, and, finally, 5 oz. lucerne chaff per head. In all groups, except the one which received lucerne chaff, the effect of these rations was so severe that the sheep had to be withdrawn from the experiment after a month, in order to avoid very heavy losses. Food intake became negligible and the sheep were extremely weak and lethargic. Even though a generous ration of lucerne chaff and oats was then offered, many still refused to eat and some 10 per cent died. The group which received 5 oz. lucerne chaff as a daily supplement in addition to the straw, actually gained slightly in weight during the first month. They were continued on this ration for some five months but eventually lost weight and several died.

(vi) Groups of adult Merino wethers were fed on drought rations comprised solely of grain, to supply 4.0 lb. starch equivalent (or food units) per week The grains used were wheat, oats, maize, barley, and grain sorghum. All groups were fed at weekly intervals for 154 days. The group which received oats maintained the highest body weight and those which received grain sorghum the lowest; wheat, maize, and barley were intermediate. It was of interest that the groups fell in the same order as regards the time taken to consume the week's ration; those fed on oats consumed i in five days, those on grain sorghum in two days, and those which received wheat, maize, or barley consumed it in three to four days. These results may have a valuable practical application in relation to drought-feeding, apart from cost. Because of the longer period taken to consume the ration, oats should be more advantageous under conditions of total drought, when no other feed is available. On the other hand, under less severe conditions, when some dry feed is still available, there may be some advantage in using grain sorghum, because the rapidity with which this is consumed may encourage the sheep to seek other feed whilst waiting for the next grain ration. The difference in liveweight between the oat-fed and the sorghum-fed groups at the termination of the trial was only 8 lb This was reduced to 4 lb. within a week, when the two groups were fed on 50:50 chaff and wheat, thus demonstrating that much of the apparent difference in weigh had been due to "intestinal fill".

(vii) The nutritive value of lucerne chaff and wheaten chaff was compared in 50:50 mixtures with wheat, in rations fed at drought levels. No significan difference was detected.

(viii) Under drought conditions it would sometime be of great advantage if the lambs could be weaned much earlier than usual. An experiment was therefore carried out with the lambs derived from the ewes in the experiment. They were allotted in chronologica order of birth to groups which were to be weaned a four, eight, and twelve weeks of age on to rations o 50:50 lucerne chaff and whole wheat. A sub-group weaned at four weeks, received a ration of lucerne chaff crushed wheat, and milk powder. Weaning at eight and twelve weeks was generally successful but only abou 30 per cent. of those weaned at four weeks, in either group, survived. Those which survived weaning a four weeks throve almost as well as those weaned a eight and twelve weeks, but it appears that few lamb can survive the sudden change at an age when rumen development is still slight.

9. Toxicity of Large Rations of Wheat.

(Division of Animal Health and Production.)

This work, undertaken at the Animal Health Research Laboratory, Melbourne, has shown that wheat gorging by sheep is quickly followed by the development of a predominantly lactobacillary type of fermentation in the rumen, a sharp fall of ruminal pH to about 4 and a rise of ruminal lactic acid to 1 per cent. or more and, furthermore, that the ruminal changes are soon followed by a rise of blood lactate, a fall of blood pH and plasma bicarbonate, and a severe fall of blood volume with eventual death. The hypothesis has been considered that the rise of blood lactate and the fall of blood pH and bicarbonate are due, at least in part, to direct absorption of enterogenous lactic acid from the bowel, although the possibility has not been lost sight of that hypoxia associated with reduced blood volume may also play a part. The evidence obtained so far indicates that the mere maintenance of the ruminal pH at 4 even for prolonged periods, by means of periodic additions of lactic acid, may lead to only mild and temporary acidosis without haemoconcentration; even though some lactic acid eventually passes along the bowel, the pH does not fall. When lactic acid solution at pH 3 was introduced directly into the duodenum by means of a catheter at a suitable rate for many hours, severe acidosis, lactacidaemia, and some fall in blood volume were produced from which recovery occurred after the infusion was terminated. When abomasal contents adjusted to pH 3 with lactic acid (4 per cent.) were infused directly into the duodenum, acidosis, lactacidaemia, and temporary haemoconcentration followed. The typical "wheat gorge" signs, including severe haemoconcentration, followed when the infusion into the duodenum was carried out with a mixture of ground wheat and ruminal fluid which had been allowed to ferment 24 hours at 37° C., after which the pH was 4.4 and the lactic acid amounted to 1.35 per cent. After twenty hours, this sheep had reached a moribund state, but was restored to health by changing the infusion to normal ruminal fluid.

These experiments show that it is not necessary for the wheat to ferment in the rumen itself, that the effect of introducing fermented wheat mash into the duodenum is more severe than that of lactic acid solution of much higher lactate concentration, and that although, as has been described in earlier reports, lactic acid can be absorbed directly from the rumen, the amounts so absorbed do not appear to be sufficient to produce severe effects. Since measurement of ruminal motility showed that ruminal atony may supervene even five and a half hours after consumption of a large toxic dose of wheat, it would seem that there is little chance that large amounts of wheat will pass onwards unless a very large feed is consumed quickly, and this is what usually happens in the field.

10. CHRONIC FLUOROSIS.

(Division of Biochemistry and General Nutrition.)

Deep bore waters sometimes contain harmful amounts of fluorides. The effects of additions of sodium fluoride to the drinking water supplied to grazing mature sheep are being studied in order to determine the safe limits of fluorine in stock-waters. Three concentrations have been investigated: 0.3, 10, and 20 parts of fluorine (as fluoride) per 1,000,000 of water to cover the range frequently encountered. Neither the health nor productivity of the experimental animals was adversely affected by the high concentrations during the two-year course of experiment; and no signs of dental changes or untoward effects of chronic fluorosis were discernible at autopsy. Subsequent chemical examination of selected bones and teeth from these animals has revealed small increases in their fluorine content. This, however, does not alter the conclusion that drinking water which contains as much as 20 p.p.m. fluorine is innocuous for mature grazing sheep provided that the animals have reached the age of three and a half years before they have access to it.

A corresponding experiment with younger sheep is being continued. The groups which comprise this trial have been confined since birth to waters containing 0.3, 10, and 20 p.p.m. fluorine, and their mothers drank nothing but these waters during the whole period of their gestation. At present, the animals are three years old, and there is no significant difference between their mean body weights, nor was there at last shearing any significant difference in their wool production. However, the mottling of the enamel and the wear of their incisor teeth, and the selective abrasion of their molars, mentioned in the previous Report, have become more obvious. These effects are more marked in the group which has access to the water containing 20 p.p.m. fluorine, but even in these the deterioration of the teeth has not led to any adverse effect on the health of the sheep, notwithstanding dry grazing periods throughout two summers. Another experiment with breeding ewes has indicated the water containing 20 p.p.m. fluorine has little, if any, adverse effect on their reproductive capacity.

11. MINOR ELEMENTS IN ANIMAL NUTRITION.

(Division of Biochemistry and General Nutrition.)

(*a*) *Cobalt and Its Relationship to Vitamin B_{12} Deficiency in the Sheep.*—(i) *The Production of Vitamin B_{12} in the Rumen.*—Vitamin B_{12} differs chemically from vitamins B_{12a} and B_{12b} only in the nature of the radical which is attached rather loosely to the cyanogen group of the complex molecule. These analogues are readily intra-convertible and they have about the same, if not identical, capacity to provide nutritional demands of animals and of the micro-organisms that require vitamin B_{12}. Other cobalt-containing metabolic products of micro-organisms are known which behave very differently from vitamin B_{12} although chemically they are related to it. These vitamin B_{12}-like substances occur along with vitamin B_{12} as products of bacterial activity in the contents of the rumen. Some of them have no activity in the animal organism, though for certain micro-organisms their potency may exceed that of vitamin B_{12}. The estimation of vitamin B_{12} by microbiological assay methods is thus seriously complicated.

A special study is being made of these factors, and for this purpose procedures for producing a state of extreme vitamin B_{12} deficiency in the rat have been evolved which have rendered possible critical rat assay methods. More recently, colleagues at the National Institute of Dairying, situated in the University of Reading, have courteously sent us cultures of a chlorophyll-bearing flagellate *Ochromonas malhanensis,* which requires vitamin B_{12} and will not react to the vitamin B_{12}-like substances, and have made available, before publication, their recently evolved methods. These and the animal assay methods evolved here will render more direct those investigations which aim to solve some of the physiological problems associated with cobalt deficiency in ruminants.

(ii) *Vitamin B_{12} in the Tissues of Normal and Cobalt-deficient Sheep.*—Because of interference by vitamin B_{12}-like substances in the rumen contents, the two microbiological assay methods, in which a mutant of *Escherichia coli* and *Lactobacillus leichmannii* respectively are used as test organisms, give very different results and neither can be taken as a final estimate of vitamin B_{12}. These substances are not stored in the tissues and so the "vitamin B_{12} activity" estimated by microbiological assay is probably in fact due to vitamin B_{12} *per se.* Assays by either method give the same result with liver extracts. Although the number of estimations is not as yet very great the concentration of vitamin B_{12} in the livers of normal sheep has been found to vary over a range from 0.3 to 1.4 $\mu g.$ vitamin B_{12}/g. fresh tissue. The concentrations in the livers of cobalt-deficient sheep are very much lower; in some it has been found to be reduced to 0.04 $\mu g.$ vitamin B_{12}/g. fresh tissue.

(iii) *Vitamin B_{12} and Cobalt Deficiency in the Sheep.*—A series of experiments has been conducted in the annexes at the main laboratory and at Hackney, and in the pens at the Waite Institute to study further the physiology and biochemistry of the relations between vitamin B_{12} and cobalt ingestion in the sheep. The results have shown unequivocally that the syndrome of cobalt deficiency is, in fact, due to vitamin B_{12} deficiency.

The sheep's requirements of vitamin B_{12} are being assessed, and it is already evident that the potency of the vitamin is increased over 100-fold if it is injected into the muscles rather than administered as a drench or incorporated in the foodstuffs. Obviously it is either modified by bacterial activity within the rumen or its absorption from the intestinal tract of the sheep is very poor. If the latter proves to be correct, the extraordinarily large amount of vitamin B_{12} which seems to be required by ruminants would be explained. Although the experimental work has not been completed, it is already apparent that the sheep's requirement of vitamin B_{12} is not very great if the vitamin is administered parenterally.

The influence that the cobalt concentration of the ingesta has on the rate of production of vitamin B_{12} and of the vitamin B_{12}-like substances in the rumen are being studied by observations on sheep in which permanent fistulae have been established. The fall in the rate of production of "vitamin B_{12} activity" in the rumen contents when the cobalt content of the rations is decreased below a critical level is quite rapid; the deficiency symptoms appear in the animal, however, only after its reserves of vitamin B_{12} become depleted, and this depletion takes several months. Sheep in a state of extreme cobalt deficiency respond dramatically to intramuscular injections of vitamin B_{12} without any alteration in the rate of "vitamin B_{12}" production in the rumen. There is no response to massive doses of pteroylglutamic acid or to choline.

(iv) *Cobalt Deficiency Under Grazing Conditions.*—It has been established that 100 μg. of vitamin B_{12} injected intramuscularly thrice weekly will rapidly restore normal health to sheep that have been allowed to develop extreme symptoms of cobalt deficiency while grazing on the very deficient pastures at Robe: and that 50 μg. of vitamin B_{12} injected either thrice weekly or once weekly will maintain sheep in good health indefinitely on these deficient tracts. After establishing a relatively high vitamin B_{12} status in this way, mature animals remain healthy under these grazing conditions for approximately six months without further treatment; whereas the storage of vitamin B_{12} in the tissues after dosing sheep under identical grazing conditions thrice weekly for a similar period with the equivalent of 1 mg. Co/day was sufficient to maintain them for only approximately three months after the treatment ceased. Experiments to determine the sheep's minimum requirement of vitamin B_{12} under natural grazing conditions are being conducted at Robe.

(v) *Control of Cobalt Deficiency.*—An experiment which aims to determine the most economic way to control cobalt deficiency under natural grazing conditions indicates that massive doses of cobalt administered as a drench at monthly intervals may suffice for mature ewes: though their lambs suffer if they are not dosed at more frequent intervals.

(*b*) *Copper Deficiency in Sheep.*—(i) *The Effect of Molybdenum on the Copper Metabolism of Sheep Depastured at Robe.*—The observations mentioned in previous Reports have been confirmed; the administration of molybdenum (as sodium molybdate) to sheep on these pastures increased the onset of the symptoms of copper deficiency while paradoxically increasing the sheep's capacity to retain copper in its tissues and blood stream. This phenomenon is being investigated in rats under controlled laboratory conditions; and the findings are likely to lead directly to a more complete understanding of copper metabolism.

A preliminary examination of the copper concentration of livers of a proportion of the lambs from the ewes which constitute the experimental groups mentioned in previous Reports indicate that molybdate interferes little, if at all, with the passage of copper from the ewe through the placenta to the foetus. These observations will be repeated to finally establish this important point.

(ii) *Iron Metabolism in Copper-deficient Sheep.*—The tissues of the sheep, like those of other animals, lose their normal ability to utilize iron and so accumulate relatively large deposits of iron which is functionally inert. A series of experiments has shown that these deposits are rapidly utilized on resumption of a normal copper status.

(iii) *The Absorption of Copper by the Sheep.*—Experiments reported in previous résumés have indicated that absorption of copper from the intestinal tract into the blood stream is much more rapid and efficient if copper salts are introduced into the abomasum than if introduced into the rumen. Copper introduced in dilute solution directly into the blood stream is removed relatively rapidly and becomes almost totally deposited in the liver.

(*c*) *Field Experiments, Robe.*—Most of the field experiments mentioned above have been carried out at the field station at Robe. In addition a number of others have been conducted.

The Effect of Dressing Copper-deficient Pastures with Copper Sulphate.—The object is to determine, over a period of years, the efficacy and staying power of dressings of copper sulphate applied to the native pastures of the deficient tracts. The copper status of the experimental animals grazed on the pastures dressed in 1939 and 1940 with 14 lb. of copper sulphate per acre was assessed again during the year under review, by estimating the copper concentration in the liver from samples removed by biopsy. The mean concentration of copper in the livers of untreated sheep on these pastures was barely adequate (34 μg. Cu/g. liver dry wt.); the copper status of the control sheep which received the equivalent of 4 mg. Cu/day in addition while depastured on the same area was high (522 μg. Cu/g. liver dry wt.).

(*d*) *Field Experiments, Borrika.*—Experiments similar to those reported above were started some years ago at Borrika, on a different type of soil typical of the incipiently copper-deficient terrain of the Murray Mallee region. This experiment will be continued until frank symptoms of copper deficiency become apparent in the untreated sheep which constitute the experimental animals depastured there. At the end of 1952 the livers of the untreated sheep on the untreated area contained a mean concentration of 34 μg. Cu/g. dry wt.; the fleeces of some of these sheep had by then begun to show signs of copper deficiency. Whereas the corresponding concentration of the livers of sheep that had grazed on the immediately adjacent pastures which had been treated with copper some years previously was 64 μg. Cu/g. dry wt., and all of these sheep were growing normal wool.

(*e*) *Field Experiments, "Brecon", Keith, South Australia.*—The site at "Brecon", which is typical of the huge areas of very deficient terrain in the Ninety-Mile Plain that are being developed according to the procedures indicated by the Division, was made available through the generosity of the Australian Mutual Provident Society; and the activities there are at present devoted entirely to a carefully controlled experimental study of the growth, production, and welfare

' sheep depastured upon three types of pasture similar those that are being used for the development of ese virgin tracts. The overall problems of pasture evelopment have been solved; it is now essential to ve close attention to the health of the flocks and erds on these newly developed pastures so that dis-bilities may be recognized and steps taken to rectify em before they assume very serious proportions.

The soils of this area are singularly short of zinc nd copper, and these elements must be added to the hosphatic dressings employed there for the establishment of pastures. As other lines of our investigations ggested that the cobalt status of flocks on this terrain ould rarely, if ever, become completely secure and ight be expected at times to become sufficiently low seriously influence their health and productivity, the rst series of experiments was designed to investigate e cobalt status of experimental flocks depastured on ree different types of pasture which were sown r this purpose. A few months after the experimental nimals were transferred to these prepared areas the ymptoms of a serious nervous malady appeared in dividuals in the pastures in which the perennial grass *halaris tuberosa* predominated. The malady Phalaris staggers" had been described previously occur spasmodically with season and terrain in other reas where *P. tuberosa* had been employed for pasure improvement but, although its potential danger ad been recognized, and the fatal consequence which equently ensued had been attributed to a toxic subance in the young shoots of the *Phalaris,* little or othing definite was known of its aetiology or of the eason for its spasmodic occurrence, and no effective eans of controlling the disease had been suggested. he experiments during the first year indicated that a pplement of cobalt which was provided as a drench half of the flock, protected the animals from the xic effects—none of the cobalt treated animals eveloped the malady, whereas 70 per cent. of those ntreated developed the nervous symptoms and 50 per nt. died of the malady. There were similar outbreaks the second year, and the protective effects of cobalt ere confirmed.

At present the experimental work is taking the main ends—one to exploit, in terms of application, the nowledge we already have, and the other to learn ore of the nature of the malady and of the mechanism rough which the protective action of cobalt is fected. There is already proof that cobalt must be lministered frequently if it is to effectively protect eep from the toxic influences of *P. tuberosa*. A ench containing 7 mg. Co administered once each eek afforded complete protection over a period when per cent. of the untreated controls developed the sease; in these circumstances relatively enormous oses (280 mg. Co) provided once each month had no otective influence. Long-term trials have been arted to examine the possibility that top-dressing the *halaris* pastures in this locality with cobalt sulphate ight lessen the incidence of the malady. In January, 53, cobalt sulphate in aqueous solution was sprayed amount equivalent to 1 lb. cobalt sulphate/acre to half of a 300-acre area of *Phalaris*-subterranean over pasture in which there was a serious outbreak staggers the year previously. At the end of April, 0 mature Merino wethers were placed in each area. bout a month later many of the sheep on the untreated ea had developed the malady; this flock was removed d another substituted. No cases have yet appeared the flock which has been confined for the whole eriod on the cobalt treated area. The behaviour of perimental flocks on these areas will be observed ring the next few years, for it is probable that a actical solution of the very serious problem of Phalaris staggers on these newly developed tracts will eventually take the form of a simple, direct procedure such as this.

There is a wide scope for more intensive studies and a number of experimental investigations have been started to clarify further the aetiology of this interesting malady. The first series of these aims to determine finally whether the protective action of cobalt is effected within the intestine through its influence on the intestinal flora or whether it is *in fact* an abundant supply of the cobalt-containing vitamin B_{12} in the tissues which favours metabolic destruction of the toxic principle before it can influence the nerve cells.

12. INFERTILITY AND PHYSIOLOGY OF REPRODUCTION.

(Division of Animal Health and Production.)

(*a*) *The Influence of Nutrition on the Performance of Breeding Ewes.*—At the Animal Health Research Laboratory, Melbourne, Merino ewes were fed daily and weekly, on drought ration (*see* Section 7) for some weeks prior to mating and throughout pregnancy. Some groups were given additional quantities of the same ration (10: 90 wheaten chaff and wheat) before and during mating ("flushing"), and before lambing ("steaming up"), or during both periods. There were no striking differences in the rates of conception or of lambing.

(*b*) *Seasonal Variation in the level of Fertility in Merino Sheep.*—(i) The series of observations carried out by the Animal Health Research Laboratory, Melbourne, which involved four matings at three-monthly intervals at the Tooradin Field Station, has been completed. The mating periods corresponded to the winter, spring, summer, and autumn respectively. Ten per cent. of the ewes failed to mate during the winter mating period and 59 per cent. during the spring mating period, whereas only 1 per cent. failed to mate during the summer and autumn mating periods. Of the ewes which actually mated and which were still available at lambing, 84 per cent. of those which mated in the winter, 58 per cent. of those which mated in the spring, 91 per cent. of those which mated in the summer, and 96 per cent. of those which mated in the autumn lambed. Some of the ewes were autopsied three-four weeks after mating. Others were X-rayed at 12, 15, and 18 weeks. In this manner it was determined that the failure to lamb of ewes which had mated was associated very largely with failure in conception and embryonic mortality within three-four weeks after mating. Loss of this type was higher at the winter and spring matings than it was at the summer and autumn matings. There may have been a small loss of foetuses between four and twelve weeks, but it is unlikely that there was any loss between 12 weeks and lambing. In relation to ewes mated, the number of lambs which were born alive in the different groups was as follows—winter mating, 72 per cent.; spring mating, 22 per cent.; summer mating, 93-95 per cent.; autumn mating, 95 per cent. The 30 pregnancies which derived from the spring mating did not include any multiple pregnancies. Four to five per cent. of multiple pregnancies occurred at each of the other matings. Few lambs were lost from the groups mated in the winter and the spring. Substantial losses occurred from the groups mated in the summer and the autumn.

(ii) Ewes of the two groups which were joined with the rams at the end of October and in mid November respectively did not begin to mate until the end of the first week in December. There was no difference in the course of mating in the two groups.

(iii) Among Merino ewes reared from earlier matings and now 4-5 years old, there were 53 per cent. of twin births from matings at the Werribee Field Station during May and June.

(*c*) *Effect of Administration of Hexoestrol on the Outcome of Pregnancy.*—Investigations at the Animal Health Research Laboratory, Melbourne, have shown that of seven aged Merino ewes to which hexoestrol was given intramuscularly sixteen weeks after mating, one aborted four days later; two died one and twenty days later respectively—each contained a foetus which was apparently normal; two gave birth to lambs—in the one instance still-born twin lambs, in the other a small weak lamb which failed to suck; and two failed to lamb, but were each found to contain a decomposing foetus 159 and 162 days respectively after mating.

(*d*) *Induction of Heat in Spayed Ewes with Stilboestrol and Progesterone.*—This work was undertaken at the Animal Health Research Laboratory, Melbourne. A dose of 2 mg. of stilboestrol intramuscularly at fortnightly intervals produced heat regularly over a period of many months in at least three or four spayed ewes and frequently in all four. Progesterone in doses of 2.5-22.5 mg. given at the same times as doses of 0.25-2.0 mg. of stilboestrol did not augment the response in any way.

(*e*) *Studies on Mechanism of Fertilization.*—This work has continued throughout the year at the Animal Health Research Laboratory, Melbourne.

(i) *Cytology of Fertilization and Early Cleavage.*—The distribution of the nucleic acids in fertilization and early cleavage has been studied in the rat egg, by the use of ultraviolet micrography for living eggs and by the Feulgen reaction for fixed eggs. The nucleic acids show no distinct localization during fertilization, but a structure containing a high concentration of desoxyribonucleic acid, and probably analogous to Casperson's "nucleolus-associated chromatin", becomes increasingly evident about the nucleoli during early cleavage.

(ii) *The "Capacitation" of the Sperm.*—It has now been confirmed that the sperm in the rat and rabbit requires to spend some time in the female tract before it becomes capable of penetrating the zona pellucida. It is further shown that the time required for the capacitation of rat sperms is between two and four hours, and of rabbit sperms apparently about 4 hours.

(iii) *The Passage of Sperms through the Female Genital Tract.*—The distribution of sperms in the female tract at various times after mating has been determined in the rat, rabbit, and ewe. The results support the idea that a restrictive action on the number of sperms reaching the eggs is an important function of the female tract. The parts of the tract responsible for the largest drops in sperm concentration are the utero-tubal junction in the rat, the utero-tubal junction and the isthmus of the tube in the rabbit, and the cervix and the isthmus of the tube in the ewe. In the rat it appears that the restrictive junction of the tract is relaxed somewhat as the end of the fertile life of the eggs draws near.

(iv) *Polyspermy in the Rat and Rabbit.*—This appears to be the first investigation specifically on polyspermy in mammals. After normal mating, the incidence of polyspermy in rats is about 1.2 per cent. and in rabbits about 1.4 per cent. If mating is prevented until the time of ovulation or a few hours later the incidence rises sharply to about 8.8 per cent. in the rat and about 16.4 per cent. in the rabbit. In the rat polyspermic eggs undergo apparently normal development up to at least the eight-cell stage.

(v) *The Reaction of the Zona Pellucida to Sperm Penetration.*—The zona pellucida of the rat changes after the penetration of the first or first few sperms and becomes impenetrable to further sperms. The zona reaction is about as rapid in the mouse egg as in the rat egg, and is apparently more rapid in the sheep egg. On the other hand, the rabbit zona shows no apparent reaction to sperm penetration.

(vi) *The Artificial Activation of the Rat Egg.*—It is well known that the shrinkage of the vitellus and the formation of the second polar body, which normally only occur in consequence of sperm penetration, can be provoked experimentally. This artificial activation is being studied in rat eggs, with particular reference to their fertility.

(*f*) *Studies on Foetal Age in the Guinea Pig, Mouse, and Rabbit.*—These studies are designed to provide information which will make it possible to determine the foetal age, in attempting to relate foetal weight, foetal age, and placental development. These studies form a useful background to the projected investigation upon the relationship between placental development in sheep and the viability and development of the foetus, as an aspect of the neonatal mortality in sheep.

13. Breeding and Genetical Studies.

(Division of Animal Health and Production.)

(*a*) *Inbred Flocks of Australian Merinos.*—This work was undertaken at the McMaster Field Station, Badgery's Creek, New South Wales.

(i) *The Flocks.*—The mean Wright's coefficient of inbreeding in the flocks is now approximately 25 per cent. The programme of inbreeding without selection has so far achieved no greater degree of uniformity for fleece characters among the inbred animals than was present in the original group of ewes from which they were derived. It is now proposed to practise divergent selection within some of the groups for high and low levels in certain characters, determined as a result of fleece measurements being carried out on animals in the various flocks.

(ii) *Top-crossing.*—Data for mean birth and weaning weights from progeny by 25 per cent. inbred and other non-inbred sires show no differences. No animals are old enough to provide fleece data. Although the number of sires used so far in this experiment has been small, low fertility appears to be more prevalent among those which are inbred. The experiment is continuing.

(*b*) *Inheritance of Component Fleece Characters.*—At the McMaster Field Station, Badgery's Creek, New South Wales, matings continue for the purpose of building up numbers in the F_1 and F_2 generations. Data so far obtained from fleece measurements indicate that for the fleece characters, yield and wax and suint ratio, the F_1 generation has similar mean values to those of their longwool parents. Mean values for staple length and fibre diameter in F_1, although of an intermediate nature, are closer to the mean value for the longwool than that for the finewool parent. Mean values for number of crimps per inch and density of fibre population in F_1 are more truly intermediate. Crude mean values for the various characters in the three generations are summarized in the Table in which, for the sake of brevity, numbers of animals in generations and standard deviations have been omitted.

FLEECE CHARACTER EXPERIMENT DATA.

Generation.	Character.						
	Yield. (%)	Wax Ratio.	Suint Ratio.	Staple Length (cm).	No. of Crimps per Inch.	Mean Fibre Diameter.	Density (Fibres/cm²).
P_1 (Finewool)	55	66.5	3.6	8.4	17.0	14.8	5150
P_2 (Border Leicester)	75	11.4	10.4	15.2	3.7	31.0	850
F_1 ..	76	12.7	11.5	9.9	10.9	24.0	2830

Observations on the ratio of primary to secondary ollicles, made on skin biopsy specimens taken from eventeen new-born F_2 lambs, do not reveal that segre-ation which would indicate a simple method of nheritance for follicle ratios.

(c) *Hairiness of Fluffy Tip.*—This investigation ontinued at the McMaster Field Station, Badgery's reek, New South Wales. The final drop of F_2 progeny re not yet of an age to permit of their classification r fleece sampling. These final observations will take lace during the ensuing year.

(d) *Sheep-breeding Studies.*—The Section of athematical Statistics has again continued to work n close collaboration with the McMaster Animal ealth Laboratory, Sydney, in studies on sheep breed-ng. In these studies, productive characters are being neasured, including clean wool weight and its com-onents (staple length, fibre diameter, number of fibres er unit area of skin, body size, and degree of skin vrinkles), wool cover of points and face, lamb produc-ion per ewe, and lamb survival rate.

One major project at the National Field Station, 'Gilruth Plains", Cunnamulla, Queensland (Project AB1), was described in last year's Report and some results were given. This project has continued on the lines described, with the addition of two new groups in the family series, where selection is for one character at a time. The existing groups have demonstrated that the characters fibre number and staple length can be present in different combinations, high fibre number and long staple being characteristic of one group, high number and short staple of another, low number and short staple of a third. The two new groups were designed to investigate the possibility of breaking the strong negative association which has been consistently found between fibre number and fibre diameter.

During 1952-53, ram lambs dropped in AB1 were again left entire at marking, but were sampled and shorn at twelve months of age instead of sixteen-eighteen months. On the basis of these measurements numbers were reduced by approximately half; the remainder were remeasured at sixteen-eighteen months, when the final selection of sires was made. This procedure will be repeated, and the correlation between measurements at the two ages will determine the reliability of final selection at twelve months of age for the characters under consideration.

Some of the results reported in 1951-52 were confirmed in 1952-53, not only from AB1 but also from other data examined. Histological examination of skin sections was made for the first time not only in AB1 but also on samples from sheep at the Australian Pastoral Company's property, "Noondoo", Dirranbandi, Queensland, where the General Manager has for many years been basing selection of his stud sheep on measured characters. These records were made available to the Organization for analysis, and facilities were also offered for taking both fleece and skin samples. The skin sections from AB1 have confirmed the selection on fibre numbers in the family series, the high fibre number group having a mean secondary: primary follicle ratio of 20.2 and the low fibre number group, 14.8. Skin sections from ewes in AB1 were taken in the family series only, and there were not sufficient animals in the "maternally handicapped" class (twins and progeny of maiden ewes) to check the observation previously made on fleece samples that the number of fibres per unit area is lower in such animals. In the "Noondoo" figures, however, a lower secondary: primary follicle ratio was found for the "handicapped" animals on skin sections.

The "Noondoo" data cover measurements on clean wool weight for unclassed two-tooth ewes in a number of years, together with their body weight, staple length, and fibre diameter. The degree of skin wrinkling and folding has been scored, though not in the same grades as in C.S.I.R.O. techniques; the level of wrinkling is not high, however, and variation is slight. Although fibre number has not been measured, the data provide indirect confirmation of previous observations in AB1 that fibre number is the component which has the greatest influence on variation in clean wool weight.

During 1952-53, a study has been made, on data from various sources, of factors influencing the birth and survival rate of lambs in the Merino. From AB1 and "Noondoo" figures it has been possible to study the influence of the age of the ewe on the ratio of ewes lambing to ewes mated, L, on the ratio of lambs surviving to lambs born, S, and on the ratio of twin births to all births, T. In both sets of data L showed a rise from two to five years.

The incidence of twins in both sets of data showed an increase with age of dam up to about eight years. Ewes will be retained in AB1 till the end of their tenth year until further evidence has been collected on the relation between productivity and age. The "Noondoo" figures demonstrated differences between sire groups in survival rate, though no such differences have been found in AB1.

The "Noondoo" data have yielded evidence on a character not previously measured in AB1, namely, "point cover", or the extent to which wool covers the belly and limbs. Sheep have been scored on two scales, each of five grades, for "point cover" and "face cover". The two measures are highly correlated in these data, and large sire-group differences have been found, indicating a high measure of heritability.

(e) *The Study of Strains of Merino Sheep in Several Environments.*—Work on this project is proceeding satisfactorily at the Regional Pastoral Laboratory, Armidale, New South Wales. Standard observations on production and reproduction are being made. Subjective gradings of fleece characters continue to be made by a worker from the East Sydney Technical College. An analysis of the 1949-50 season's data, separating the additive effects of strains and locations from the interactions among strains and locations, has been completed. There were highly significant interactions of strains and locations in nearly every characteristic studied. Semen examinations are now being made each year of all rams being used for mating together with a reserve for each.

The collection of body measurements and wool samples from sheep in the studs from which strain trial sheep were purchased, was carried out in 1952 in four cases. Observations in the trial are being made on a per head basis. Economic adaptation of strain to environment depends also on production per acre or on the cost per unit of product in terms of fodder consumed. To measure the intake-output relationship of the strains under intensive individual feeding conditions, a preliminary attempt has been carried out at "Gilruth Plains" on group feeding using wethers from the strains as experimental material.

(f) *Studies on Hornedness in Sheep.*—Studies on the development of hornedness with age, on the inheritance of hornedness, and on any possible associated character, have been continued, at the National Field Station, "Gilruth Plains", Cunnamulla, Queensland.

14. GENETICS OF SHEEP.

(Animal Genetics Section.)

The Animal Genetics Section has undertaken a survey of sheep throughout Australia which is designed to provide knowledge of the total variation between sheep throughout Australia in quantity and quality of wool production, and the fraction of such variation which can be apportioned to genetic and other causes. Some 25 studs have offered their help, and if sufficient teams can be organized these 25 will all be sampled this shearing; measurements of skin and wool will be taken using the standard techniques developed at the Fleece Analysis Laboratory, Villawood, and Wool Biology Laboratory, Randle-street. When this investigation is completed it should be possible, with already existing information, to give a fairly accurate forecast of the probable effect of sheep-breeding programmes on fleece weight and quality throughout Australia.

Investigations of a more detailed kind are proceeding at Badgery's Creek. The breeding experiment being carried out by the Division of Animal Health at Badgery's Creek, in which Longwools were crossed to Merinos, has been extended by the addition of crosses between Longwools (Romneys) and Downwools (Southdown) and between Downs and Merinos. Work with the rabbit has suggested that the difference between Down and Longwools might be due mainly to a single gene difference, or at most to a character under simple genetic control. The object of the crosses is to determine to what extent the differences between the three types of sheep can be explained as follows:—(1) Downs differ from Longwools essentially by a single genetic character which is typified by slow growth of fibres in follicles, none of which penetrate deeply into the skin. Primaries and secondaries both penetrate to the same extent in all Downs and grow fibres of much the same length. In Longwools, follicles do not necessarily penetrate the skin to the same depth, they penetrate more deeply than in Downs, and primaries often penetrate more deeply than secondaries. (2) Merinos are essentially Longwools but with a greatly increased density; this increase is due to an increase in secondary fibres, and is the main difference between Merinos and other Longwools. The genetic control of this difference is a completely open question but is probably more complicated than that of the difference between Downs and Longwools.

By tracing the growth of follicles at intervals of a fortnight in 40 lambs, from birth to eight months, it has been found that all secondaries are in being by the sixth week. The ratio of primaries to secondaries at birth is little different in finewool Merinos from the ratio in Romneys, so that the processes which distinguish Longwools from Merinos produce their effect mostly between birth and six weeks of age. Limited experiments were made to try to alter the ratio of primaries to secondaries by treatment at this stage, but these have given inconclusive results. This work must be repeated on more lambs before anything definite can be said.

15. Biological Studies of Skin and of Wool.

(Division of Animal Health and Production.)

(*a*) *Comparative Studies of Breeds of Sheep: An Experimental Study of Lincoln, Corriedale, Polwarth, and Fine Merino Ewes.*—The statistical analyses of the data from the extensive series of observations at the Sheep Biology Laboratory, Sydney, have now been substantially completed. The material is in a forward state of preparation for publishing.

(*b*) *Comparative Studies of Breeds of Sheep: Field Studies of the Skin and Fleece.*—Flock sample studies of significant skin and fleece characters have been continued at the Sheep Biology Laboratory, Sydney. The principal breeds of significance in Australia have been covered and in particular the main strains of the Australian Merino. These direct studies of skin and fleece characters are supplemented by studies of the ecology of the Australian sheep population from available recorded sources. This work provides complete data on the geographic distribution of the stud Merin flocks, the numerical strength of the various strains o Merino, the identity of parent studs, and the relativ numerical strength of the daughter studs springin essentially from such sources to form the family group within each strain.

(*c*) *Analysis of Skin and Fleece Characters in a Australian Merino Stud.*—From the accumulate results of successive years of sampling at the Shee Biology Laboratory, Sydney, a standard age-grou (fifteen to eighteen months) among the ewes of thi stud, a small highly select group of ewes has bee separated on the basis of past laboratory (skin section measurements and mated to a ram selected with the ai of similar criteria. The first stock from this exper mental mating will soon be available for study.

(*d*) *Experimental Histology of Skin and Hair.*— These investigations are centred at the Sheep Biolog Laboratory, Sydney.

(i) *Behaviour of Skin Autografts in Sheep.*—In a attempt to separate the effects due to origin of particular area of skin and those due to present location, a series of skin autografts was made on Merin sheep. The tentative conclusions are—The temporar changes produced in grafted skin by the grafting procedure, such as epidermal hyperplasia and fibr shedding, were similar in kind to those reported b Medawar in the rabbit, though they differed in degre and took about twice as long. In lambs and youn sheep the grafts behaved according to origin wit respect to type of wool, fibre thickness and rate o growth in length. Even after considerable loss an replacement of follicles in a graft, the orientation o follicle groups and the ratios of secondary to primar follicles tended to follow the original pattern of dono skin. In skin which is otherwise independent of loca influences, fairly permanent changes could be brough about in the pigmentation of epidermis and woo through the activity of melanophores in adjacent skin

(ii) *The Biology of Mammalian Melanophores.*— The pigment-producing melanophores are cells whos behaviour has been studied extensively in the lowe vertebrates but much less so in mammals. They ma be readily observed in living tissue cultures of th skin from suitable mouse embryos. By such mean the differentiation, movement, and pigment accumulation of melanophores is now being studied, and th transfer of pigment granules from melanophores t the epidermis and the developing hairs observe directly.

(iii) *Genetic Modifications in Hair Follicle Development in the "Tabby" Mouse.*—A sex-linked gene *Ta* recently discovered in the mouse by Falconer, produce tabby markings in the coat of female heterozygote (*Ta/x*) and an apparently different set of modifications in female homozygotes (*Ta/Ta*) and male homozygotes (*Ta*). The modifications of "tabby" homozygotes and hemizygotes include absence of two o three types of pelage hair follicles and a reduction i the number of facial vibrissae. It has been postulate that these effects are exactly the same as those in th genetically distinct "crinkled" mice and are produce in the same way by suppression of hair follicle formation during two separate periods. Tissue cultur studies support this hypothesis of follicle suppressio in the embryo and young mouse at certain well-define stages. Closer study revealed that the phenotypically different "tabby" heterozygotes showed a simila though greatly reduced effect of the gene *Ta*.

(iv) *The Population Dynamics of Hair Follicles in the Skin of Sheep.*—Studies are continuing on the possibility of intrinsic competition effects occurring within the follicle population.

(*e*) *Experimental Physiology of Skin and Hair rowth—Hormonal Regulation of Wool Growth.*—his investigation centred at the Sheep Biology Labora-ory, Sydney, has shown that the anterior pituitary land secretes hormones which are necessary for normal vool growth. Fractionation of sheep pituitary tissue as been undertaken to isolate the hormones that will estore wool growth in the hypophysectomized sheep. arious fractions are at present being assayed iologically for their content of known pituitary ormones. An intradermal assay is being developed or measuring their effects on wool growth.

16. Sheep Diseases.

(Division of Animal Health and Production.)

(*a*) *Caseous Lymphadenitis of Sheep.*—Observa-ions have been continued at the Animal Health esearch Laboratory, Melbourne, on the experiments hich have been mentioned in previous Reports. In he group brought into the experiment in 1947 and laughtered in October, 1952, there was no significant ifference in the incidence of infection in the vaccinated nimals, in those passing through a rested paddock ff-shears, or in the control animals. The results of ll the experiments considered as a whole show that he methods of control have a very limited value. It is ossible that a more valuable and reliable vaccine may, time, be evolved. In one experiment a living equine train of *Corynebacterium ovis* was used for the accination of guinea-pigs. Some protection was btained. Five equine strains were then tested with he result that two and possibly three of these were ound to be worth further study. It was found that oses which are lethal on subcutaneous injection may e given safely intradermally. Some observations have een made with living ovine strains given intradermally sheep. It was found that by these means lesions the regional lymph nodes occur more consistently han from infection of wounds, or from subcutaneous noculation.

(*b*) *"Toxaemic Jaundice" of Sheep.*—This co-perative investigation has been continued at the nimal Health Research Laboratory, Melbourne. nvestigation of natural outbreaks has continued by the ivision of Animal Health and Production as a co-perative effort with the veterinary research staff of he Department of Agriculture of New South Wales. ome of the outbreaks have been due to the develop-ent of uncomplicated chronic copper poisoning in razing sheep, some have been due to straightforward eliotrope poisoning, but others have been due to a erminal haemolytic crisis of chronic copper poisoning sheep which have become susceptible as a result of revious grazing of heliotrope. Investigation of the wo diseases has progressed along the following lines.

(i) *Chronic Copper Poisoning.*—The observations t the Field Station, Cobram, Victoria, have been oncluded. These observations, which were continued ver three successive seasons, have shown that early ermination of subterranean clover and an acid eaction in the soil are not of themselves sufficient to ause a rapid increase in the rate of absorption and etention of copper by the grazing sheep.

In the field experiment at Tumbarumba, New South Vales, a dry season again spoiled the planned experi-ent. However, it proved to be practicable to increase he molybdenum content of the subterranean clover y including sodium molybdate in the superphosphate sed to top-dress some of the pasture. The resultant ncrease in the molybdenum intake of the sheep exerted definite limiting effect on their copper storage. The ean increase in liver copper concentration in a group f sheep grazing the molybdenum-treated pasture was 65 p.p.m. compared with an increase of 440 p.p.m. in the sheep grazing the pasture top-dressed with superphosphate only.

Laboratory study of the factors influencing the storage of copper in the liver by sheep has continued. In following up the earliest observations that the nature of the plant material consumed had a definite influence on the amount of copper stored, it was found possible to separate an "active" fraction from lucerne hay. This was found to have a readily demonstrable effect on molybdenum excretion and was identified as inorganic sulphate. Feeding experiments with sheep showed that neither molybdenum nor inorganic sulphate alone will limit the storage of copper in the liver, but the two together will prevent the storage of copper and at appropriate dose levels will cause copper to be lost from the liver.

Both molybdenum and inorganic sulphate occur in pasture plants in amounts which vary over a very wide range of values. These variations are being examined along with intensive studies of the quantitative relationship between molybdenum and sulphate intake on the one hand and copper storage on the other.

(ii) *Heliotrope Poisoning.*—In the last field experiment at Barooga, New South Wales, the effects of exposure to heliotrope grazing were studied in groups of several breeds of sheep through three successive seasons. The observations were terminated in August, 1952. It was found that over the two and a half years of the experiment, with animals grazing the natural pastures in which *Heliotropium europaeum* occurred, there was no significant difference in the death rate, from all causes, between two strains of Merino ewes, Border Leicester x Merino crossbred ewes, and Dorset Horn x Merino crossbred wethers. With smaller groups, however, which were studied more intensively, it was found that the Merinos were more resistant to heliotrope poisoning than the crossbreds when both were forced to eat heliotrope grown in pure stands. Furthermore, although the Border Leicester and Dorset Horn crossbred sheep stored more copper in their livers after they had grazed for two seasons on pastures containing heliotrope than did control groups which had not been exposed to heliotrope, the grazing on the heliotrope pastures did not affect the copper status of the Merinos. Supplying a drench containing 100 mg. Mo/day to crossbred sheep in this environment did not materially reduce the amount of copper stored nor was there any evidence of any deleterious effects of the consumption of this amount of molybdenum over a period of two and a half years in this environment. It may not, however, be safe to give sheep 100 mg. Mo/day in an environment which was supplying a higher intake of inorganic sulphate.

The toxic doses of the alkaloids heliotrine and lasiocarpine for rats have been accurately determined and it has been confirmed that, although lasiocarpine is the more acutely toxic, the hepatitis in rats which closely resembles the disease in sheep is produced by repeated small doses of heliotrine. A similar result is produced by a similar series of injections in rats by the appreciably less toxic *N*-oxide of heliotrine.

(*c*) *Sheath Rot of Wethers.*—Plans were made at the Animal Health Research Laboratory, Melbourne, to continue the observation on a flock of wethers in the Western District of Victoria. However, few wethers became affected with sheath rot during the spring of 1952 and the projected observations had to be abandoned. Some laboratory observations were carried out on the effects of hexoestrol in wethers as it was considered desirable to determine if epithelial tissues in the penis and sheath of wethers undergo changes similar to those found in sheath rot. Tablets of hexoestrol were implanted in the subcutaneous tissues in a number of wethers. All the animals developed characteristic urogenital abnormalities, which in no way resembled the lesions seen in sheath rot.

(*d*) *Footrot in Sheep.*—Results of previous research at the Animal Health Research Laboratory, Melbourne, on the control and eradication of footrot in flocks have been scorned by some groups of producers. Inquiries and inspections were carried out in the field to determine the cause of failure of the application of the results and to determine if further research were necessary. Visits to affected properties in areas of New South Wales where the disease had become widespread in recent years clearly indicated that failure to control it was not due to the recommended methods being at fault but to the fact that the owners or managers had not been instructed in their use and had not properly grasped the principles involved.

Some cases of footrot have been established and fresh strains of the causal organism, *Fusiformis nodosus*, are being isolated. The bactericidal effect of various antibiotics on the organism will be tested *in vitro* and any which are effective at low concentration will be tried on natural cases of footrot, both systematically and by local application. Present indications, however, are that *F. nodosus* is readily destroyed provided the lesions are adequately exposed by paring, and that no antiseptic will be effective unless this is done.

(*e*) *Epididymitis in Rams.*—Seven rams with epididymal lesions have been carefully examined at the McMaster Animal Health Research Laboratory, Sydney, four from centres in New South Wales and three from Victoria. Each ram was mated to ewes before slaughter. The ewes were artificially inseminated in addition, because the semen quality of the rams was poor and it was desired that the ewes should conceive in order to discover whether they would subsequently abort their lambs. All ewes have remained normal so far and no vaginal or other lesions have been detected. From the lesions of two of the seven rams an abortus-like organism has been recovered and it was obtained from the semen of one of them before slaughter. The others yielded nothing of interest but this may have been due to the age of the lesions. The abortus-like organisms closely resemble those recovered from similar cases described by workers in Queensland. Indications have been obtained, however, that both the New South Wales and Queensland strains have at least one common antigen with *Brucella abortus* though they are not closely related to it, and that the New South Wales and Queensland strains are much more closely related but are probably not identical antigenically.

17. INTERNAL PARASITES.

(Division of Animal Health and Production.)

(*a*) *Studies on Anthelmintics.*—These investigations have continued at the Regional Pastoral Laboratory, Armidale, New South Wales.

(i) *Phenothiazine.*—Further observations have been made on the relation of particle size to the anthelmintic efficiency of phenothiazine. In trials with *Haemonchus contortus, Oesophagostomum columbianum, Chabertia ovina,* and *Ostertagia* spp. it has been found that if the particle size exceeds 25-30 μ most of the parasites survive. Further observations are needed regarding *Trichostrongylus* spp. but indications are that results will be similar. A number of commercial preparations of phenothiazine has been examined and several were found to contain high proportions of coarse particles. When tested under laboratory conditions, such preparations showed low anthelmintic efficiency.

(ii) *Mode of Action of Phenothiazine and Related Compounds.*—The chemical, physico-chemical, and synthetic work is done at the Chemistry School of Sydney University and the products are screened against *Syphacia* spp. in mice at the McMaster Laboratory. The organic chemical and physico-chemical work on phenothiazine, phenoxazine, and the phenoselenazines has now been completed except for the preparation of 3-iodophenothiazine, which is in progress. The oxidation potentials of this series of 30 compounds have been determined. Tests against *Syphacia* in mice have been carried out, usually at dose levels of 2 g./kg., but considerable difficulty has occurred in obtaining adequate levels of *Syphacia* infestation in the mice and this phase of the work has lagged accordingly. Results, so far, indicate that there is a region of maximum anthelmintic activity between +600 and +800 mV oxidation potential. None of the diphenylamines tested has shown appreciable activity except 4-4′-dimethyldiphenylamine, which was also found effective against *H. contortus* in sheep in 10 g. doses but doses of 18 g. were toxic. In all, some 82 compounds have been prepared for testing and the potentials of 30 of them have been determined by oxidation with bromine or dichromate and potentiometer readings. Attempts to measure the oxidation potentials of the diphenylamines were unsuccessful, due to the extreme instability of their oxidized forms.

Because these studies on the mode of action of phenothiazine have suggested that its anthelmintic effect may result from its ability to form relatively stable semiquinones, some complex quinones were tested for possible anthelmintic efficiency in sheep.

Certain quinones, e.g. 1-8-dihydroxyanthraquinone and 1-2- dihydroxyanthraquinone, cause diarrhoea in sheep and it was thought that their administration, together with phenothiazine, might enhance anthelmintic action against *Oe. columbianum.* No such effect occurred but both the 1-8 and the 1-2 compounds, themselves, proved to be highly effective anthelmintics against the large bowel parasites of sheep, *Oe. venulosum, Oe. columbianum, C. ovina,* and *Trichuris ovis* when doses of 1-2 g. were administered into the rumen. These doses were effective in the absence of any purgative effect and were without effect on nematodes other than those which inhabit the large bowel. Larger doses of 2.5-5.0 g., however, were effective against *H. contortus* also. The relatively selective action of these compounds on large bowel parasites, and especially the effect on *T. ovis* which is resistant to commonly used anthelmintics, including phenothiazine, is of considerable interest.

(iii) *Anthelmintic Tests with Miscellaneous Compounds.*—Several additional compounds, which there was some reason to believe might have anthelmintic activity, were tested against *H. contortus* in sheep.

(iv) *Observations on the Techniques of Drenching Sheep.*—The short oesophageal tube, devised for administration of phenothiazine to sheep and mentioned in the previous Report, is now being produced in one form or another by commercial firms. If the sheep's mouth is first swabbed with 5 per cent. copper sulphate, drenches administered through the tube pass into the abomasum, whereas, without such prior stimulation of the oesophageal-groove reflex they almost always enter the rumen, even when the drench itself contains copper sulphate. A comparison was made between "fast" and "slow" drenching with solutions containing copper sulphate through drenching instruments which did not include the short oesophageal tube. The "slow" method involved injecting a few millilitres of the dose into the mouth and waiting 3-5 sec. before giving the remaining 25-30 ml., and the dose passed into the abomasum in thirteen out of fourteen sheep. When the "fast" method was used, the whole dose was given as quickly as the sheep could swallow it and in seven out of twelve sheep it passed into the rumen. The "slow" method, which is the one advocated when drenches containing copper sulphate with nicotine sulphate or arsenic are used, is, therefore, about twice efficient as the “fast” method, with consequent nservation of costs and labour despite the slightly nger time required to drench the flock.

(b) *Studies on Resistance to Nematode Parasites.*—hese investigations have continued at the McMaster nimal Health Laboratory, Sydney. It is now parent that the development and degree of sistance to trichostrongylosis is influenced by the umber of larvae administered and the frequency of ministration. Experiments with previously worm-free mbs indicated that doses of 1,000-2,500 larvae once or vice a week for four-ten weeks resulted in infestations hich seldom persisted, and that the great majority uld then withstand a massive challenge dose of larvae, dministered some six months later. But when worm-ree lambs were given 20,000 larvae at monthly tervals their immunological response, which was good t first, became less as monthly dosing was continued ntil eventually the dose elicited little, if any, rise in tibody level. Of the eight lambs in this experiment, vo died of trichostrongylosis after the fifth dose of rvae, one after the sixth, and one after the ninth dose. was also observed that faecal egg counts in the lambs hich were given smaller doses at short intervals did t develop until administration of larvae had ceased. erological tests on groups of weaners grazed on natural d improved pasture at the Regional Pastoral Labora-ry, Armidale, showed that positive reactions were ore numerous and enduring among those on im-roved pasture.

At Armidale repeated small doses or a single massive se of infective *H. contortus* larvae were administered three groups of sheep which five weeks previously d received an immunizing dose of 1,400, 11,000, or nil rvae three days after the removal of an existing un-easured population. Apparently owing to the revious infestation removed by phenothiazine the eep of the groups receiving larvae developed a nerally low but variable infestation. However, when bjected to the massive dose five weeks later these itiating doses were sufficient to prevent any build-up infestation whereas six of ten sheep which had ceived no initiating dose developed moderate infesta-ons. On the other hand, repeated small doses of larvae ministered to this uninitiated group apparently imulated resistance and prevented the development infestation.

Further observations were also made on sheep which d become resistant to *H. contortus*. Frequent blood-stamine determinations after massive challenge doses larvae revealed no rise in histamine levels. Resist-ce in such cases is not dependent, therefore, upon the lergic phenomena associated with “self-cure”. ttempts to break down their resistance by massive ses of larvae, given as a single dose, or in daily or ekly doses, failed in all of twelve sheep and their actions to the complement fixation test were not nsistent.

In relation to the “self-cure” phenomenon, it has en shown that its occurrence in sheep infested with *. contortus* is not associated with any change in pH the abomasum, and that an established infestation ith this parasite is not affected by the continuous travenous injection of histamine (9 mg. in seven urs) nor by increases in the level of blood histamine duced by “compound 48/80”. A sharp decline in ecal egg count, induced by intravenous injection of *lmonella typhi-murium* in a sheep infected with *. contortus*, was not associated with an increase in ood histamine.

It appears that resistance of sheep to *H. contortus* is t associated with the “self-cure” phenomenon, nor ith the titre of complement-fixing antibodies. Attempts find evidence of some other antigen-antibody system ve so far failed, but the work is continuing.

The effect of drenching with phenothiazine on the resistance of sheep to infestation with *Trichostrongylus* spp. is being studied at Armidale. It is clear from these trials that the abilty of weaners and lambs to resist fresh infestations is not impaired by drenching with phenothiazine.

(c) *Epidemiological Investigations.*—Field studies carried out by the staff of the McMaster Animal Health Laboratory, Sydney, have continued in Tasmania and Western Australia, in collaboration with the respective Departments of Agriculture. In Tasmania trials have been conducted on eleven properties during the year. They commenced in early summer. Worm populations, notably *Trichostrongylus* spp. and *Ostertagia* spp., tend to rise in the lambs in late spring and early summer, and lambs should, therefore, be treated about December to reduce their infestations and minimize contamination of pastures. Worm populations rise again in late summer and early autumn and the lambs should be treated again about February, when treatment can conveniently be associated with weaning. In some, but not all, trials in 1951-52 there was also a considerable increase in faecal egg counts in late winter, associated with a declining plane of nutrition. Photosensitization has occurred on several occasions among lambs in Tasmania which have been drenched with phenothiazine.

In Western Australia trials have continued on seven properties, including the Regional Field Station at Kojonup. Additional groups were included in the trials this year to provide a comparison between epidemiological changes in worm burdens and in productivity between treated and untreated sheep. In a trial the previous year, treated sheep weighed 89.5 lb. at shearing and cut 11 lb. 5 oz. of greasy wool, whereas untreated sheep weighed 77 lb. and cut 9 lb. 1 oz. Moreover, among the twenty untreated sheep there were eighteen tender fleeces, six tender skin, and six with cotted wool, compared with ten tender fleeces, one tender skin, and no cotted wool in the treated group. The trials this year commenced when the lambs were weaned in August. Worm burdens again increased in the late winter and early spring but to lower levels than last year. The unusual early summer rains of 1951 were not repeated in 1952 and faecal egg counts remained low throughout the summer. Rains in the early autumn of 1953 were followed by increased egg counts in May, with heavy infestations of *H. contortus* in the Toodyay district and of *C. ovina* in the Williams and Cranbrook districts. Further data are needed before the most effective timing of preventive treatment can be ascertained, but indications from the first two years' work are that ewes should be treated before lambing, that lambs should be treated in July and again at about the end of March, and that, if good rains occur during the summer months, sheep may require treatment about three weeks later.

Epidemiological observations have also been continued on the Southern Tablelands of New South Wales. Another trial was concluded during the year with lambs born in late winter. When first examined, at about seven weeks of age, appreciable worm infestation was already present, as indicated by faecal egg counts. Worm populations rose during the spring, mainly due to infestations with *Ostertagia* spp. and *Trichostrongylus* spp., and remained moderately high during the summer. Infestations with *C. ovina* and *Oe. venulosum* appeared during the summer. After rains in the autumn, the levels of infestation declined. This occurred in the previous two years also and is believed to be due to “self-cure” resulting from increased intake of larvae when autumn rains have favoured their development. Liveweight again showed a decline in the summer, due mainly to a reduced plane of nutrition, but that worm infestations also contributed to it was shown by the higher liveweight of treated sheep compared with controls. In hoggets there was only a slight rise in faecal egg counts in the summer, chiefly due to *C. ovina* and *Oe. venulosum*. The low level of infestation probably resulted from resistance induced by infestation during the previous season. In addition to these observations, lambs were killed each month from September to May for total worm counts. An appreciable rise, with many immature worms of each species, was found after heavy rain in December. Thereafter, the summer was dry and no immature forms were found until after further effective rain had occurred in April. The fact that, although immature forms were then found, the actual worm burden of the sheep declined, probably indicates that "self-cure" had occurred.

At Armidale the comparison of the epidemiology of nematode parasites in sheep grazing on sown and native pastures was continued. The observations have been made on the same sheep continuously since birth in October, 1951. The dry spring and summer of 1951 resulted in a delayed onset of parasitism in both groups. *Oesophagostomum* infestation was noted to be lower in lambs grazing sown pasture up until May, 1952, and although infestations have increased there still appears to be a significant difference in favour of the sown pasture group. At the termination of the trial when the sheep are killed, this observation will be investigated further. *Haemonchus* infestations, as in the autumn of 1952, continued at appreciably higher levels in the native pasture group during the spring and summer of 1952-53. This position was temporarily reversed following rains in February when "self-cure" was observed in the native pasture whereas a number of the sown pasture sheep acquired fresh infestations. *Trichostrongylus* infestations have followed much the same pattern in both groups during the period of observations and are at low and comparable levels at the present time.

A preliminary trial was commenced at the Falkiner Memorial Field Station on the epidemiology of helminthiases in sheep on irrigated pastures. Two groups, each of twenty young wethers, have been under observation since February, one group on irrigated pasture and the other on native pasture. During the first three months, faecal egg counts in the group on irrigated pasture rose to double the count of those on natural pasture. The rate of liveweight increase in the group on natural pasture was more than double that of the group on irrigated pasture. It is not believed that the additional worm burden of the sheep on irrigated pasture is solely responsible for their relatively poor increase in weight during a period of adaptation, but it has probably had an appreciable effect. Total counts of *Trichostrongylus* spp. have been made in sheep of both groups at monthly intervals. There has been a progressive increase in both groups but whereas the count in sheep from the irrigated pasture has increased from 915 to 5,680, the increase in sheep on natural pastures has been from 300 to 1,340.

Trials in 1951 and 1952 at Armidale have confirmed earlier observations at Cherry Hill on the removal of *Oe. columbianum* from sheep grazing green oats. During 1952, the effect of a *Phalaris*-subterranean clover pasture and a red clover pasture were studied in addition to green oats. On both pastures there was some shedding of *Oe. columbianum* in comparison with controls grazing native pastures but these pastures were less efficient than green oats. Several factors may influence the shedding of worms. The ingestion of green oats led to an acid reaction of the faeces and this may be of importance. Shedding of worms commenced soon after grazing on the green oats began and was associated with softening of the faeces. There was a comparable softening of the faeces in sheep grazi *Phalaris*-subterranean clover pasture and red clov pasture, but removal of worms was much less effectiv Weight increases in the sheep on green oats we slightly greater in 1951 and considerably greater tha the controls of 1952. The high nutritive value of th green oats, *per se* does not seem to be the importa factor in effective removal of worms.

(*d*) *Studies on* Ostertagia *spp.*—Investigations o the histotropic phase of these species, mentioned i the previous Report, have been completed at th McMaster Animal Health Laboratory, Sydney Third-stage *Ostertagia* larvae enter the gastric pit and glands in the pyloric and cardiac regions of th abomasum between 72 and 96 hours after administration. Some also penetrate glands in the abomasa fundus. This initial migration is the most regula feature of the histotropic phase. Thereafter, worm may leave the mucosa quickly or remain ther undeveloped for periods which may exceed thre months. Others may develop to the adult stage in th mucosa and migrate into the lumen of the abomasun in that form, or as the fourth instar.

(*e*) *Systematic Studies on Parasites affecting Sheep*—These studies have continued at the McMaste Animal Health Laboratory, Sydney. Because littl is known of the species of Coccidia in Australia sheep, a survey has been commenced. So far, *Eimeri arloingi* has been found most commonly but smal numbers of *E. parva*, *E. nina kohl yakimovi*, *E. faure* and *E. intricata* are also found. In addition, cocyst which correspond to the descriptions of *E. crandalli* Honess 1942, and *E. ah-sa-ta* Honess 1942, have bee observed. *Trichostrongylus rugatus Mönnig* 1925, common parasite of sheep, has been found in the smal intestine of calves at a Sydney abattoir and may b common in cattle in New South Wales. This is th first record of the occurrence of *T. rugatus* in cattle An index has been completed of all members of th genus *Cooperia*.

(*f*) *Distribution of Nematodes in the Small Intestin of Sheep.*—Information has been collected at th McMaster Animal Health Laboratory, Sydney, o the distribution in the small intestine of shee of those species of *Cooperia* which are normall parasitic in cattle. It is believed this will aid elucidation of the factors which influence localization o species in the small gut and possibly also in regar to problems of host specificity.

(*g*) *Studies on the Bionomics of Free-living Stage of Nematodes of Sheep.*—A study of the ecology o nematode larvae has commenced at the Regiona Pastoral Laboratory, Armidale, New South Wales.

(i) *Hatching of Eggs and the Development o Infective Larvae.*—Faeces have been exposed in dens pasture (6 inches high), a short pasture (2 inche high), and on a bare pasture (grass cut at base, leavin mat only). These are compared with faeces expose under optimum moisture conditions in a dense pastur and with control cultures in an incubator. Temperatures in pellets in exposed faeces follow closely thermograph records in an adjacent Stevenson screen an these records are being used until microclimatic record are available. Observations have indicated that ther would be a more continuous production of infectiv larvae where there is a dense pasture cover limitin evaporation and that "mass hatching" of eggs o *Trichostrongylus* spp. can occur under these conditions depending on rainfall distribution. There was n similar "mass hatching" with *H. contortus*.

(ii) *Vertical Distribution of Infective Larvae.*—Small *Phalaris*-clover plots trimmed to 4.5 inches in height are inoculated fortnightly with infective larvae and the grass, mat, and soil subsequently examined e vertical distribution of larvae is correlated with croclimatic conditions. The distribution was found be reversed as between inoculation following dry d wet periods.

A direct measure of infective larval populations on stures grazed with different stocking rates is also ing attempted and an infective dose of larvae fficient to cause clinical symptoms, has been recovered om artificially contaminated pastures.

(*h*) *The Pathology of Helminthiasis in Sheep.*—udies at the McMaster Animal Health Labora- ry, Sydney, on worm-free sheep and on sheep hich had been dosed with larvae of *Trichostrongylus* p. revealed that a hypocythaemic anaemia occurred all the infested animals, together with a fall in the ematocrit reading to below 20 per cent. in the more avily infested sheep. The rate at which dye (Evans' ue) disappeared from the blood stream was greater infested sheep than in controls. This suggested that infested sheep there was an increase in capillary rmeability or that blood was removed by the para- tes. The hypothesis is being examined by serological eans. The hypocythaemic anaemia in infested sheep as not due to the repeated injections of dye, nor to eekly bleeding. Blood analysis showed no significant fference in the electrolyte balance (Na, K, Cl) tween control and infested sheep nor in infested eep at different stages of the infestation. No con- ant histopathological changes have been found in the testine of sheep carrying light infestations with *richostronglylus* spp. but further material from avily infested sheep is to be examined.

(*i*) *Parasite Physiology and Toxicology.*—Research the McMaster Animal Health Laboratory, ydney, on the biological activity of complex ns, which may have valuable toxicological or chemo- erapeutic applications, has continued in collabora- on with the Chemistry School of the University of ydney and the Zoology Department of the University Adelaide.

Studies on the Biological Activity of Complex Ions. -A wide range of additional compounds, of different emical composition and belonging to the bi-, tri-, uadra-, quinqua-, and sexadentate groups have been sted for toxicity to mice. All these compounds were able but they differed in symmetry, charge, and ater or fat solubility. All were toxic to some extent, ut particularly the fat-soluble and highly charged ompounds. Their toxic effect resembles that of curare. mong asymmetric compounds, the *d*-form is much ore toxic than the *l*-form. There is evidence to sug- est that the less toxic *l*-form tends to block the toxic ffect of the *d*-form, if given in advance of it, whereas ub-lethal doses of the *d*-form, given in advance, nhance the toxicity of the *l*-form.

The difference in toxicity between the *d*- and *l*-forms f the same compound was thought to result from ifferences in their ability to penetrate membranes. his was supported by the results of experiments with compound labelled with ^{106}Ru. After intraperi- oneal injection, the *d*-form reached a much higher evel in the blood than the *l*-form. Side effects of the njection of these complex compounds in rats were rapid hyperglycaemia and glycosuria, which reached peak shortly after injection on successive days. evere glycosuria continued even when blood glucose ad subsided below the renal threshold. After death, egenerative changes were found in the renal tubules nd hepatic cells. Much lipoid had also been lost from he suprarenals and there was secondary prolifera- ion in the lymph nodes. In both mice and rats well- arked but transient polycythaemia occurred after njection. All these effects appeared to be related to he charge of the compound. There was no strong correlation between the effect of the compounds on blood-glucose levels and their toxicity and, when the lethal effect of the more toxic fat-soluble compounds was prevented by simultaneous administration of eserine, hyperglycaemia and glycosuria still occurred. Desoxyribonuclease was not affected by cationic complexes. Urease was only inhibited by asymmetric compounds. Succinic dehydrogenase was affected, but whereas the *l*-form of a compound inhibited this enzyme, the *d*-form activated it. These effects did not seem to result from surface action but possibly from disturbance of the spatial relationship of the protein molecules in the enzyme solution.

The complex Ru (o-phen)$_3$Cl$_2$ was found to inhibit growth of *Brucella abortus* strain 19 and preliminary tests indicated that multiplication of certain bacteriophages was also inhibited.

18. External Parasites.

(Division of Animal Health and Production.)

(*a*) *Studies on the Itch Mite of Sheep* (Psorergates ovis).—Attempts at the McMaster Animal Health Laboratory, Sydney, to determine the duration of the stages in the life-cycle of this parasite have not, as yet, been successful. The information given last year concerning distribution on the sheep has been confirmed and, in addition, it has been found that the itch mite may be present on any part of the head and face of the sheep. The investigation on the bionomics of *P. ovis* has been completed and can shortly be published.

(*b*) *The Face Louse of Sheep* (Linognathus ovillus). —During the year it was possible to investigate at the McMaster Animal Health Laboratory, Sydney, an outbreak of this form of louse infestation. It is not a common parasite in Australia and does not seem to have been investigated here previously. The complete life cycle occupies about five weeks. Eggs hatch in eleven-fifteen days under optimum conditions. Populations on sheep increase during the winter and reach a maximum in spring. They decline during the warmer months and a great reduction in numbers follows shearing. When populations are at a minimum, these lice are only found on the hair-covered face, but when the peak of population is reached they are also found in the wool about the face, head, and upper parts of the neck. If the lice are found elsewhere on the body it is due to mechanical transmission and they soon die. Infestations may be so heavy that the face, head, and upper neck appear brown in colour. Even heavy infestations do not appear to worry the sheep unduly and the economic importance of the parasite is probably slight. A single trial in the affected flock suggests that BHC, at the concentration generally recommended for dipping, will eradicate *L. ovillus* provided the dipping technique ensures proper saturation of the face, head, and neck, but this finding requires confirmation. The usual plunge-dipping technique, in which sheep pass rapidly through the bath and the heads are immersed once, is so inadequate that many sheep in the group so treated were still infested when re-examined some three months later.

(*c*) *Studies on the Ecology of Ectoparasites.*—An attempt is being made at the McMaster Animal Health Laboratory, Sydney, to determine the main characteristics of the environment to which ectoparasites that spend their complete life cycle on their hosts are exposed, and to study their physiological adaptation thereto. *Damalinia ovis* and the sheep are the parasite and host under investigation at present. It has been shown that the presence of fibre is necessary before oviposition can take place freely but there appears to be no physiological specialization which prevents the eggs from hatching when laid on fibres other than wool or hair. The greatest number of eggs are deposited at temperatures in the vicinity of 37.5° C. The best hatch appears to occur between 35 and 38° C., but this requires closer examination. Some eggs of *D. ovis,* but none of *L. ovillus* will hatch at 40° C.

(*d*) *Systematics.*—Descriptions are being prepared at the McMaster Animal Health Laboratory, Sydney, of the eggs, nymphs, and adults of those lice of the genus *Linognathus* which are found on domestic animals. Suitable diagnostic keys will then be drawn up.

(*e*) *Studies on Control of Ectoparasites by Means of Insecticides.*—At the McMaster Animal Health Laboratory, Sydney, the value was tested of jetting sheep in long wool with BHC to control *D. ovis* infestations for two or three months, until they could be shorn. Appreciable infestations with body lice when sheep are carrying several months' fleece create a difficult problem. It is often impracticable to shear them and dipping involves a greater risk than with recently shorn sheep besides seriously staining the fleeces and reducing their value. Yet, if the lice are not controlled, the irritation they cause results in considerable damage to the fleece through biting and rubbing. Moderate to heavy body-louse infestations occurred in some 200 wethers which were carrying about nine months' wool and which, for experimental reasons, could not be shorn for some two or three months. Each wether was jetted, well into the fleece, from poll to tail and to about midway down the sides, with BHC at four times the usual concentration recommended for dipping. Approximately ½ gallon was used on each sheep and the results were very satisfactory. The louse population was reduced to negligible proportions and irritation was eliminated. There was no recurrence prior to shearing, some three months later, after which the sheep were dipped.

(*f*) *Demodectic Mange in Sheep.*—*Demodex ovis* is commonly present on sheep in small numbers which remain unnoticed. It rarely causes any clinical signs and there are very few records of it. Such a case occurred at the Laboratory during the year, in a sheep which was known to have harboured this parasite for a considerable period. Owing to its rarity, a description of the case is being prepared by the McMaster Animal Health Laboratory, Sydney, for publication.

19. Protection Against Blowfly Strike.

(Division of Animal Health and Production.)

Attempts were made at the Veterinary Parasitology Laboratory, Yeerongpilly, Queensland, to obtain a high incidence of this type of strike by wetting sheep in a shower dip to induce fleece rot and releasing large numbers of laboratory-bred *Lucilia cuprina.* Although an appreciable incidence of fleece rot was produced, these attempts were not successful in producing a high incidence of body strike for experimental work. It was found that by using indole plugs as an attractant, a satisfactory incidence of strike could be obtained. A trial to test the protection given by various concentrations of DDT and BHC was inconclusive; the work is proceeding.

20. Entomological Study of the Sheep Blowfly.

(Division of Entomology.)

The following is a brief summary of the work which has been carried out on the sheep blowfly by the Division of Entomology. The ecological studies under (*a*) are described more fully in Chapter IX., Section 3.

(*a*) *Ecological Studies.*—A large-scale trapping experiment using newly emerged *Lucilia cuprina* marked with fluorescent dusts has been carried out, and has yielded much useful information. The experiment included observations on several other blowfly species and the bush fly, *Musca vetustissima.*

(*b*) *Life History Studies of Blowflies.*—Studies on the breeding habits and life history of several species have been continued.

(*c*) *Protection against Body Strike.*—Final insectary tests were carried out on the persistency of DDT incorporated in L.B.E. branding fluid.

21. Other Investigations.

(Division of Animal Health and Production.)

(*a*) *Neo-natal Mortality in Lambs.*—These studie have been continued at "Chiswick" Field Station Armidale, and elsewhere in the Division of Anima Health and Production. At "Chiswick", in 1951, ewe of several strains, mated and lambed under pen conditions, reared a higher percentage of lambs up to markin time than station flock ewes mated and lambed unde paddock conditions. Under pen conditions there wa both a higher percentage of lambing ewes and a lowe death rate in the lambs.

A study was commenced of the effects of differen husbandry practices at mating and lambing on th percentage of ewes lambing as well as on lamb mortality Merino ewes from two to seven years of age wer brought under study. The husbandry practices are se out as follows.

(i) *Paddock Mating and a Modified Paddock Lambing.*—A shelter shed with three attached yards locate in a 350 acre paddock was used during lambing. Ewe were shut in the largest yard at night and each mornin the normal ewes and their lambs were removed to second paddock. Ewes and lambs requiring specia attention were retained in the smaller yards.

(ii) *Paddock Mating and Lambing.*—Ewes an lambs were inspected twice daily and assisted wher possible.

(iii) *Pen Mating and Lambing.*—The mating of th 150 ewes was in a paddock ⅔ acre in size. The lambin was carried out in pens, 60 by 40 feet, with a shelte shed available for use in inclement weather.

(iv) *Mating on Sown Pasture and Pen Lambing.*— The mating of 147 ewes was in a 46-acre paddock o sown pasture and the lambing was under condition similar to the previous treatment.

(v) *Later Lambing off Shears and in Wool.*— Lambing in these groups was three weeks later than in th previous treatment. The sheep lambing in-the-woo carried eleven months' wool and were run unde paddock conditions with the other group.

An average of 95 per cent. of ewes of all age-group in all treatments lambed with the exception of the two year-old ewes mated three weeks later which gave 72 per cent. lambing. Only in the groups mated o sown pastures was there an appreciable number of twi and then only in the three- and four-year-old ewes. Th ewes grazed the sown pastures fourteen days prior mating. The percentage of lambs lost of lambs bor varied according to the age of the ewe and the metho of husbandry from 2 per cent. in the four-year-old ewe lambed off shears to 36 per cent. in the two-year-ol ewes paddock mated and lambed. Disregarding age ewe, the method which gave the highest loss of 23. per cent. was that in which the ewes were paddoc mated and lambed. Later lambing in wool also gave high death rate of 21.3 per cent. The other metho gave a death rate between 10 and 18 per cent., but th differences had little if any significance. In genera there appeared to be no dominating cause of death.

(*b*) *The Effect of Grazing Management on Pastu and Animal Production.*—This is a co-operative invest gation between the Regional Pastoral Laborator Armidale, New South Wales, and the Division of Pla Industry (*see* Chapter III., Section 15 (*c*)). Th effects of different rates of stocking, rotational grazin and grazing in different flock sizes on the health an production of Merino sheep grazing native pasture an the production of the pastures have been studied. Th trends reported in previous years continued in th fourth year. The better liveweight gains with light stocking rate were maintained.

ıe size of flock trial which compares sheep in flocks 4, 8, 16, and 30 terminated at the end of the third . In the final year the lower body weight in the sheep flock was not so great.

) *Studies on the Production of Native Pastures, in Conjunction with Sown Pasture.*—Earlier ies at the Regional Pastoral Laboratory, Armidale, South Wales, on the native pastures of the New land region have shown that, even at relatively light s of stocking, sheep weights decline to a low level vinter and with stocking rates fixed by this critical ter period much of the summer production is not zed. The critical winter period makes the breeding Ierinos on native pasture alone impracticable.

n co-operation with the Division of Plant Industry Chapter III., Section 15 (*c*)) a study is being le of the production of native pasture grazed in junction with increasing proportions of sown ture (3.9, 15.5, 30.8, and 57.1 per cent.) by a compo- flock of breeding ewes, weaners, and wethers. The ture and animal production on both the sown and native pasture is being measured. This investiga- commenced in April, 1953.

VIII. CATTLE.

1. General.

Cattle both for beef and for dairy products play an portant part in the Australian economy. Population reases and the importance of maintaining exports phasize the need for research into problems of beef duction. Particular attention is being given to estigation of cattle raising in the tropical areas in rth Australia where climatic and agrostological tors are unsuitable for sheep, and where beef is the in primary industry. The Organization's work on tle problems has been carried out within the Divi- n of Animal Health and Production, mainly in Animal Health Laboratory in Melbourne and the terinary Parasitology Laboratory in Queensland e Sections 2, 3, 4, 6 and 7 below). The Division of tomology has been concerned with work on the cattle k (*see* Section 5 below). The work of the Division Plant Industry on pastures is also of great portance to the cattle industry (*see* Chapter III.). e work of the Animal Genetics Section on beef cattle described in Section 8 below.

2. Cattle Diseases.

(Division of Animal Health and Production.)

(*a*) *Pleuropneumonia of Cattle.*—The experiment ing undertaken at the Animal Health Research boratory, Melbourne, on the possible value of phylized (i.e. optimally desiccated) vaccine, has been ncluded by subjecting the 30 animals to challenge nebulized virulent culture. The main conclusions e that standard pleuropneumonia vaccine may be eserved by this means for a period of at least 27 onths and that, when the dried vaccine is reconstituted r use, the resuscitated organisms are capable of ving rise to local tail reactions, to complement- ation responses, and to immunity. In the particular periment, each of these types of response was less an is usually found when fresh vaccine is used, but ot significantly so: much larger experiments would required to determine this.

To obtain information concerning the minimum ge at which cattle can be effectively immunized gainst pleuropneumonia, groups of 30 animals have een vaccinated in the age-groups 20-30 days, 40-50 ays and 5-7 months; they will in due course be hallenged. It was found that in the youngest group, x cases of swollen joints with acute lameness occurred nd in the middle group only one case, whereas none ccurred in the oldest group. It has long been known that a proportion of very young animals are likely to develop swollen joints after vaccination and that, under field conditions, death may follow; it has been assumed that death was the result of inanition through restricted feeding. However, the six animals that developed swollen joints in the youngest group eventually recovered from this, except for fibrous thickening of the originally infected joints, but five months later three were reported as showing signs of distress after exertion. One of these died suddenly but could not be autopsied; another was found to have developed extensive tricuspid valvulitis, from which the pleuropneumonia organism was recovered. The third animal had cicatricial thickening of the biscupid and the aortic semilunar valves indicative of earlier valvular infection. This experience emphasizes the risk attached to vaccinating calves at too early an age.

The rapid whole-blood slide agglutination test, which was briefly referred to in the last Report, has now been applied to many hundreds of animals and a report is to be prepared. It has proved very useful in the control of the outbreaks, not only in permitting the recognition of a high proportion of acute cases, but in allowing a rapid herd diagnosis to be made on the spot. It therefore has a useful role to play in control, although the complement-fixation test remains the best for highest accuracy.

During the year, the casual organism was examined for behaviour towards a large number of antibiotics and bacteriostatics. Following on from this, an attempt was made to treat experimental joint infections by intraruminal administration of chloromycetin kindly donated by Parke, Davis and Company. However, results were not encouraging.

It has been confirmed that, contrary to old-established views, the organism does not need fresh unheated serum in order to grow; it will grow equally well in autoclaved serum media and on the surface of heated blood agar. A long-forgotten observation of Japanese workers that egg yolk can replace serum for growth purposes was confirmed, and this was so even after autoclaving. Work on the identification of the growth factor or factors is proceeding.

Studies on the metabolism of the causal organism were concluded which, *inter alia*, have defined the role of oxygen. Although strongly aerobic, the organism lacks a cytochrome system. Carbohydrates are oxidized to acetate and carbon dioxide *via* the Embden-Meyerhof hexose-diphosphate pathway, the essential role of oxygen being to re-oxidize the reduced diphosphopyridine nucleotide formed during the oxidation of triose phosphate. In the absence of oxygen, such as might occur in large necrotic lesions in the lungs, a poor growth occurs, but very slowly, and it is thought that under these conditions, electron acceptors other than oxygen may be used. Pyruvate was broken down anaerobically by the dismutation reaction to lactate, acetate and carbon dioxide. It was found that the organism does not possess systems for the oxidation of acetate or any of the tricarboxylic acid cycle intermediates, and that the amino acid metabolism is very restricted, only serine and threonine being attacked.

During the year, 525,000 doses (0.5 ml.) of vaccine were distributed. Sufficient complement-fixing antigen was supplied gratis to laboratories within Australia and in Africa (Kenya, North Nigeria and Sudan) to test 18,060 and 24,600 cattle respectively.

(*b*) *Mastitis in Dairy Cattle.*—Work at the Animal Health Research Laboratory, Melbourne, was limited to investigating the value of various antibiotics against staphylococcal mastitis, the criterion of bacteriological cure being inability to demonstrate the organism by routine cultural methods in milk samples collected at weekly intervals for four weeks after treatment. Intensified aureomycin treatment (two infusions of 420 mg. at an interval of three days), procaine penicillin *plus* 5-amino acridine, furacin, terramycin and neomycin were examined in this way and none was found very satisfactory, in that the proportion of cures was less than 20 per cent.

(*c*) *Brucellosis in Cattle.*—The main object of this work at the Animal Health Research Laboratory, Melbourne, during the past year has been to determine whether protection conferred by vaccination during calfhood persists through the fourth year after vaccination. The vaccinated groups, together with a control unvaccinated group were exposed to natural infection, as before, from experimentally infected aborting animals. At the end of the experiment there had been 21 out of 30 (70 per cent.) of infections in the control group, 3 out of 25 (12 per cent.) in the once-vaccinated group, and 0 out of 25 in the twice-vaccinated group. Of specific *Brucella abortus* abortions, there had been 9 (30 per cent.) in the controls and none in either of the vaccinated groups. This again clearly demonstrated the value of " strain 19 " vaccination, but the difference between the two vaccinated groups was not statistically significant. Observations are being continued in these vaccinated groups for a further year.

(*d*) *Haematuria Vesicalis in Cattle.*—Work on the estimation of aminophenolic compounds in bovine urine was continued at the Animal Health Research Laboratory, Melbourne. The problem has proved unexpectedly difficult, but progress is being made.

A hypothesis is being examined that *o*-aminophenols may be the immediate cause of the bladder lesions, and in this connexion the possible carcinogenic effect of a member of this group, introduced into the bladder of mice as waxy pellets, is under investigation.

(*e*) *Infectious Bovine Ophthalmia.*—Opportunities occurred during the year at the McMaster Animal Health Laboratory, Sydney, to examine cattle affected with ophthalmia in the Penrith, Richmond, Casino-Tenterfield and Wellington districts of New South Wales. From affected eyes (tears) in each of these outbreaks a bacterium was recovered which has been identified as *Moraxella* (or *Haemophilus*) *bovis*. This has been described as the cause of a similar disease among cattle in the United States of America, but had not previously been recorded in Australia. The disease was transmitted to four young cattle, which had not been exposed to the disease previously, by instilling a suspension of *M. bovis* into the conjunctival sac. Typical lesions developed in three of the four animals. The fourth showed no ocular lesions but harboured the organism in its nasal cavities in large numbers. *M. bovis* was recovered from both ocular and nasal swabs of each of the four cattle after infection, whereas it had been absent previously. All were still harbouring the organism when last examined, some months after the lesions had subsided, and attempts to reinfect two of them failed. The finding of *M. bovis* on the nasal mucosa in large numbers suggests that droplet infection, through sneezing and snorting by infected animals, may be an important factor in the epidemiology of the disease. Transmission by instillation into the conjunctival sac was attempted in sheep, rabbits, guinea pigs and mice. Only the mice were affected. Five out of six developed a typical kerato-conjunctivitis with progression to corneal rupture and formation of staphylomata in two cases. *M. bovis* was recovered from each of the infected mice. All cattle developed agglutinins to high titre as the disease progressed. A non-proteolytic, haemophilus-like organism which was isolated from one beast prior to artificial infection was shown on serological grounds to be unrelated to *M. bovis*. Drug inhibition tests by the dilution method, *in vitro*, showed that chloromycetin inhibit growth of *M. bovis* completely at 1:500,000 where the organism grew well in aureomycin at this diluti but was inhibited at 1:100,000. Treatment of ear cases with an ointment which contains 1.0 per cer chloromycetin has been uniformly successful and goo reports have been received from graziers who have use it according to instructions. In advanced case spectacular results are not to be expected but the ra of recovery has been accelerated.

3. INTERNAL PARASITES.

(Division of Animal Health and Production.)

The following three investigations have been carrie out by the staff of the Veterinary Parasitolog Laboratory, Yeerongpilly, Queensland.

(*a*) *Epidemiology of Parasitic Gastro-enteritis* *Cattle.*—In Queensland, the herd at Dayboro is sti under observation and a herd at Goodna has bee brought into the experiment. The trends given by th egg counts for the various species of helminths presen in these herds have been similar to those previousl reported. The herd at Goodna has shown som extremely high egg counts, up to 6,000 eggs per g. fo *Haemonchus contortus* and up to 59,000 for *Cooperi* spp. (*C. punctata* and *C. pectinata*). These are th highest counts yet recorded in these studies.

(*b*) *Faecal Examination as a Measure of Helmint Infestation.*—Studies on the relationship between live weight, age, and faecal output have shown that eg counts may be reasonably compared in animals o different ages by applying the following corrective factors:—

Age (Weeks).	Correction Factor.	Age (Weeks).	Correction Factor.	Age (Weeks).	Correction Factor.
8	3/5	24	2	40	11/4
12	1	28	9/4	44	14/5
16	7/5	32	12/5	48	14/5
20	5/3	36	13/5		

(*c*) *Amphistomes of Cattle.*—A satisfactory technique was developed for the collection of the large numbers of cercariae required for studies on the pathogenicity of the species. It was found that cercariae were readily attracted to yellow light and could in this way be induced to encyst on glass previously painted with liquid plastic.

No symptoms were manifested by a calf given 30,000 cysts of *Paramphistomum ichikawai* in a single dose. The flukes reached maturity in 30 days. At *post mortem*, 80 days after infestation 6,000 adults were recovered from the rumen. A second calf given 130,000 cysts of this species also showed no evidence of infestation and when slaughtered twelve days after infestation yielded 5,000 immature forms collected from the small intestine.

Further evidence was obtained that amphistomes exhibit a definite rhythm in egg production. Examination of specimens during the period of minimum egg production showed degeneration of the testes and an absence of eggs in the uterus.

A new technique has been developed for counting fluke eggs in faecal samples and yields approximately four times the number of eggs obtained with techniques previously in use.

4. RESISTANCE TO CATTLE TICK INFESTATION.

(Division of Animal Health and Production.)

Studies have been commenced at the Veterinary Parasitology Laboratory, Yeerongpilly, Queensland, on the resistance by cattle to infestation with *Boophilus*

roplus, and preliminary work indicates an inherent
ural resistance and a resistance associated with an
ergic reaction to infestation. Work so far has been
fined to the allergic reaction, the development of
ich appears to depend on the number of ticks and
intervals between infestation with larvae. Blood
tamine results showed a conspicuous increase in
tamine concentration on attachment of newly
ulted nymphs and adults. The increase was present
only a comparatively brief period. Furthermore,
there was no increase during the period of rapid
gorgement by the female, it seems evident that blood
tamine concentrations are not associated with
ivary secretion by the ticks.

n hypersensitive animals the infestation is con-
erably decreased and this is due mainly to losses
the larval stage. Many larvae are removed by the
mal licking at infested areas to relieve the irritation
l others are killed through the outpouring of
essive serous exudate. The nymphs from the
viving larvae cause a typical, allergic-type, papular
ction which appears a short time after attachment.
e oedema subsides in several hours. A similar
ction occurs subsequent to attachment by the newly
ulted female. Some loss through licking also occurs
ong nymphs and adults.

. ENTOMOLOGICAL STUDY OF THE CATTLE TICK.

(Division of Entomology.)

a) Chemical and Biochemical Studies.—(i) *Bio-*
ay Tests.—Many new insecticides and formulations
re been tested in the laboratory against larval and
ılt stages of the cattle tick *Boophilus microplus,* but
ne has shown outstanding toxicity. The suscepti-
ty to insecticides of the translucent type and the
re common opaque type have been compared. The
nslucent ticks are usually found on animals carrying
ery high artificial tick infestation, and the viability
their eggs is much lower than that of opaque ticks.
a limited number of tests translucent ticks showed a
ater susceptibility to poisoning by insecticides than
ıque ticks.

ii) *Attempts to Improve Toxicity of Insecticide*
rmulations.—Chemists, working in collaboration
h the Division at the New South Wales University
Technology, supplied three new types of DDT
ulsion which, when tested in the laboratory, de-
ited a greater amount than usual of DDT on cattle
r dipped into the dilute suspensions. These
terials, together with a well-known emulsion concen-
te, were examined at Yeerongpilly—(1) by deter-
ning the LD_{50} by bioassay; (2) by spraying on to
tle and determining by microchemical methods the
tial deposit and the period the insecticide persisted;
) by comparing penetration of DDT from each
mulation through the tick cuticle; and (4) by
rying out a field trial in which a number of tick-
ested animals were sprayed and the kill of ticks and
period of protection against re-infestation assessed
a rating scale. None of these materials showed any
standing improvement on existing formulations.

iii) *Loss of Efficiency of BHC Dipping Fluids.*—
rther work has shown that the loss of efficiency in
IC dipping fluids is related to a selective depletion
the toxic gamma-isomer. This depletion is indicated
a decrease in the proportion of gamma-isomer to
al BHC in the samples, and has been observed in all
d dipping vats examined. The dehydrohalogenation
thod of estimating the BHC content of dipping
ids is, therefore, shown to be of little value for it
ermines total BHC and the gamma-isomer content
not be derived from this figure. Chromatography
he only specific method of analysis so far found satis-
tory; but this technique, although reliable, is very time-consuming. The depletion of the gamma-isomer has been reproduced under laboratory conditions and work is in progress to determine the factors responsible and the mechanism of the believed breakdown. Although the depletion is a serious problem, its practical importance is minimized by the high initial concentration of gamma-isomer in the dipping vat and by frequent additions of new material. Thus there is no marked loss of toxicity in the dipping fluid until the concentration of the gamma-isomer has been reduced to less than one-fifth of the normal concentration used.

(iv) *Resistant Strains of Ticks.*—The fifth generation of the BHC-resistant strain of ticks brought from the Rockhampton area still retains a high degree of resistance. Although the strain has not had any contact with BHC or any other insecticide since it was collected from the field, there has only been a very minor drop in the degree of its resistance. This strain is also resistant to arsenic and toxaphene, and slightly so to DDT. Although both larval and adult ticks of the resistant strain show a similar degree of increased resistance compared with the corresponding stages of the non-resistant strain, insecticides can still be used effectively against immature stages of the resistant strain because of the greater susceptibility of these stages to poisoning. The resistant strain has a similar incubation period to that of the normal strain, but the parasitic life cycle is slightly longer. Other resistant strains of tick have been found during the year. One from north Queensland was highly resistant to BHC. Another from northern New South Wales was resistant to arsenic.

(v) *Field Trials.*—Apart from the field trials mentioned in Subsection (ii) above, further tests have been completed on dieldrin, chlordane, and toxaphene. Dieldrin appears to be an outstandingly effective insecticide for ticks and, when used at a concentration of 0.2 per cent., "mortality" (as measured by the failure of engorged female ticks to lay viable eggs) was 100 per cent. and cattle were protected against re-infestation for approximately twelve days. Chlordane used at concentrations of 0.5 and 0.25 per cent. gave "mortalities" of 99 and 84 per cent. with protective periods of 7.5 and six days respectively. When toxaphene was used at concentrations of 0.5 and 0.25 per cent. complete kills of all stages of tick were obtained, together with a satisfactory protective period.

(vi) *Penetration of Insecticides through Tick Cuticle.*—The penetration of DDT and BHC through the cuticle of non-resistant and resistant strains of tick has been measured by chemical analysis. Penetration has been found to be greatly affected by the nature of the solvent used for applying the insecticide.

(*b*) *Ecological Studies and Field Experiments.*—(i) *Infestation of Undipped Animals.*—In March, 1952, six sprayed cows of British breeds were placed in a paddock of 85 acres said to have been unstocked for a number of years. Three bullocks were added in June. The animals were examined weekly between April, 1952, and February, 1953, and they were not treated for ticks during that period. The cows were infested on arrival, but lost these infestations over three weeks and carried only a few male ticks until the sixth week, when larvae reappeared. Infestations built up to high levels but were reduced naturally in winter, reappearing in mid-September. Two of the cows proved to be resistant to infestation, one highly so, and detailed observations were made on the larval and adult tick population that they carried. Comparisons were made with the susceptible animals. Large numbers of attached larvae were found on the resistant animals, but few reached maturity. There was no evidence of the susceptible animals developing any marked resistance to ticks during the five summer months. Grazing conditions were good during the experimental period and the susceptible animals, after showing signs of tick worry in October, regained condition and tolerated the infestations well. The susceptibility of the animals is not related to skin thickness measurements, as suggested overseas, nor to hairiness of coat. The animals were observed to graze together and the resistance appears to be due to skin reaction. It is not known whether resistance can be inherited. One of the resistant cows was more seriously affected by buffalo flies than the others.

(ii) *Distribution of Larvae in Relation to Habits of Cattle.*—In conjunction with the observations on undipped cattle, the grazing habits of the cattle were observed for a 24-hour period once a month, between April and November. Observations were made every ½ hour on the position and activities of the animals and the time spent by a belled animal in each 4-chain square of the paddock was recorded. On the basis of these results, larval sampling areas were set up round the "day-camp", the watering trough, and on two well-frequented grazing areas, one on a timbered flat and one on a more open ridge. These areas were sampled by the "trouser" and "blanket" methods on twenty occasions between November and March. Very few larvae were picked up round the day-camp and the trough, the greatest number being picked up on the ridge grazing area. After removal of the cattle, more larvae than previously were picked up round the trough but still none round the day-camp. Low infestations round the day-camp could be attributed to the large number of meat ants which attack engorged female ticks, while the low counts round the trough may have been partly due to constant picking up by the cattle.

(iii) *Study of "Tick-free" Area.*—An area near Duaringa has the reputation of being unusually lightly infested with ticks, although well within the tick belt, and deaths from redwater fever occur there from time to time. On an earlier visit it was noticed that parts of the area carried heavy populations of the nocturnal funnel-ant (*Aphaenogaster* spp.). Engorged female ticks were placed along a transect in this area, both in the evening and early morning. Funnel and other ants were observed taking most of them.

(iv) *Larval Survival.*—Observations are in progress on the survival time of larvae on ungrazed natural grasses. These and earlier observations suggest that less than 1 per cent. of larvae hatched will survive more than 50 days in summer and 100 days in winter.

(v) *Rotational Grazing and Frequency of Acaricidal Treatment.*—An experiment has been commenced to determine whether the frequency of acaricidal treatment can be reduced by combining treatment with a simple rotation of grazing.

6. PRODUCTION IN DAIRY CATTLE HERDS.

(Division of Animal Health and Production.)

(*a*) *Development of Zebu Hybrid Dairy Cattle.*—These investigations are being undertaken at the McMaster Field Station, Badgery's Creek, New South Wales. The dairy cattle herd now numbers 53 head. During the year three pure-bred Jersey and four pure-bred Red Poll heifers, both from high-producing herds, were purchased. The pure-bred Zebu bull was sold and his place was taken by a Sindhi x Jersey bull imported from the United States of America in 1952. The herd now comprises five bulls over two and under one year of age, 24 females in-calf or in-milk, two non-pregnant dry females, seventeen open heifers, and three calves under four months of age.

From early in 1941, there have been 170 head cattle taken into this Zebu-cross dairying herd fro all sources. Of these, 117 have been Zebu or Zebu cro breds and 53 have been British-bred cattle mainly f crossbreeding but they have also been used to supp within-herd levels of productivity for comparati purposes.

The investigation has shown that the crossbred catt are manageable under normal dairying conditions a have controllable maternal instincts and norm responses in "letting down" milk. So far as they ha gone, the production studies have shown that some the British-bred dairy heifers are no better produce than crossbred heifers which were culled. It is believ that the first possible cause for restricted producti should be overcome by the introduced Sindhi bu The crossbreds have tended to be less persistent th British-bred females and also slower milkers. Selecti may bring about improvement. The objective is develop crossbreds for production within the tropics.

(*b*) *Physiology of Milk Secretion.*—At the Anim Health Research Laboratory, Melbourne, the followi aspects have been studied:—(i) variations in residu milk and fat, (ii) effects of unequal intervals betwe milkings, (iii) the evanescence of the let-dow reaction, (iv) rise in fat percentage during milkin and (v) artificial induction of lactation in heifers.

Inter alia, it was observed that amount of residu milk and fat percentage of residual milk both increa with total yield. The relative amount of residual mi is repeatable from early to late lactation, but the regre sion of residual milk on total yield declines duri lactation. Cows in which the relative amount residual milk in early lactation is high show low pe sistence of lactation. Fat percentage of residual mi rose with total yield, but the relationship differed some respects from that of residual milk and the tot milk.

7. INVESTIGATION OF BEEF PRODUCTION IN AUSTRALI

(Division of Animal Health and Production.)

(*a*) *Beef Cattle Feeding Investigations.*—Duri the year, a senior officer of the Division of Anim Health and Production spent some six months Britain and the United States of America, where investigated methods of beef production, with particula reference to nutrition. He has compiled a full repo on his observations and much of the information resul ing from beef cattle research in Britain and norther America can be utilized in Australia with great adva tage.

(*b*) *Feeding of Stud Beef Cattle.*—Records and dat obtained after several years' collaboration with certai studs in New South Wales have been used as the bas for a publication at the extension level concerning t hand-feeding of cattle for stud and show purposes.

(*c*) *Beef Cattle Investigations in the Souther States of Australia.*—All of the twelve centres whic were to be established with funds provided by the Au tralian Meat Board (*see* previous Report) are now operation. Among the clearer indications which hav emerged so far are: Long periods of stationary declining body weights, irrespective of age, are bein recorded at some centres, whereas at others a stead increase in liveweight has been achieved in some grou by the use of conserved fodder or suitable crops whe pastures are dormant. The type of supplementary fe provided to cattle as weaners may affect the readine with which they will consume similar or other suppl ments as mature cattle. It is apparent that nutritio and management are two of the most important facto affecting beef production. Data derived from carca appraisal are providing useful information as to th st age and condition for slaughter and the require-ents of grazing and supplementary feed that are ecessary. They are also indicating interesting fferences in carcass quality which will require investi-ation.

8. GENETICS OF BEEF CATTLE.

(Animal Genetics Section.)

Some comparisons of beef cattle of European origin ith the descendants of the Zebu cattle introduced by he Division of Animal Health in 1931 are in progress. reliminary observations suggest that European cattle roduce a long fine coat in response to poor nutrition, nd a short coarse one when well fed. Such a response ight be appropriate in cold climates, it does not seem ppropriate in hot dry climates, such as that obtaining n central Queensland where poor feeding conditions oincide with the hot weather, and is certainly inappro-riate in the wet coastal area where inanition is fre-uently a result of the effect of high body temperature n appetite. The hair cycle in Zebu cattle is not yet nown. A start has been made in determining the bility of European cattle to regulate their temperature n hot climates. Considerable variation has been found etween different animals, but comparable observations n mild climatic conditions are necessary.

IX. ENTOMOLOGY.

1. GENERAL.

As in most parts of the world, the depredations of nsects are responsible for enormous losses to primary roduction in Australia. Research is therefore of he utmost importance both in the control of insect ests themselves and in the use of insects for the iological control of plant pests. The Organization's ork in this field is undertaken mainly in the Division f Entomology with head-quarters in Canberra. ollaborative work is, however, undertaken by the ivision on special problems in conjunction with other aboratories. Research on insects affecting animals is one in co-operation with the establishments of the ivision of Animal Health and Production and is eported in Chapters VII. and VIII.; the Division lays a part in the investigations on the virus disease f rabbits being studied by the Wildlife Survey Section see Chapter X., Section 2). The Division co-operates ith the Division of Forest Products in the study of ests of timber (*see* Section 18 below, and Chapter IV., Section 6).

Division of Entomology.—The past year has seen everal important developments in the work of the ivision, and there has been a change of emphasis n some work. After a meeting of Commonwealth and tate entomologists the Agricultural Council recom-nended that an attempt should be made to eradicate the rgentine ant from the infested areas in Sydney. For his campaign the Commonwealth made available to he New South Wales Government officers of the ivision, together with special equipment. The cam-aign, which was regarded as a large-scale experiment, vas undertaken during the summer of 1952-53. The iological Control Section has intensified its work n the green vegetable bug, and is endeavouring to stablish parasites of the oriental fruit fly which, it is oped, will exercise some control of the Queensland ruit fly. Laboratory experiments have shown that opulations automatically adjust themselves to destruc-ive agencies and, by so doing, reduce the effects of hem. Studies have been commenced so that theory and aboratory results can be backed up by detailed observa-ions on the factors actually operating in nature. romising new methods of controlling certain pests, otably the cattle tick and lucerne flea, have been volved. Preliminary studies have been made on the viruses affecting insects. A new virus attacking a pasture caterpillar has been discovered and it is of particular interest because similar viruses have been used in Canada for insect control. In Western Australia the Division's research officer stationed at the Institute of Agriculture has expanded his programme to include research on the lucerne flea. Dr. R. L. Beard, Senior Fulbright Fellow from the Connecticut Agricultural Experiment Station, has come to the Division to work for a period on the bacterial diseases of pasture cockchafers.

2. CATTLE TICK.

(Division of Entomology.)

The Division's work on the cattle tick is described fully in Chapter VIII., Section 5.

3. SHEEP BLOWFLY.

(Division of Entomology.)

(*a*) *Ecological Studies.*—Using the method of marking newly emerged flies with fluorescent dusts, more extensive field studies of newly emerged *Lucilia cuprina* have been carried out under typical summer weather conditions. These confirmed previous indications that the rate of spread of newly emerged flies after liberation is quite different from that of flies hardened and fed in the laboratory after emergence. A marked tendency towards irregularity in distribution in the vicinity of the liberation site was again evident, even though environmental conditions did not appear to favour spread in any particular direction. The recoveries of liberated flies and, on some days, the catches of the natural population of *L. cuprina* were greater than previously recorded. This was partly due, no doubt, to the fact that the bait was more frequently stirred than in previous experiments. Some areas of country appear to yield consistently greater numbers of "wild" *L. cuprina* than others, apart from the well-known effect of immediate location of trap. The recaptured marked specimens of known age are being studied for indications of aging, which when applied to the "wild flies" may indicate the age structure of the natural population and throw considerable light on the population dynamics of the species.

Analysis of the catch of species other than *L. cuprina* also indicated marked differences in abundance in certain areas, for instance, there were lower numbers of some of the smaller carrion-frequenting species, such as *Microcalliphora varipes* and *Peronia rostrata,* in traps in some sectors of the country than in others, and there was also a tendency for the larger *Calliphora* species to favour certain areas. It has been found that, in a few trap positions, the proportion of male flies caught is consistently higher than in the majority of traps, a phenomenon which occurs with most species.

Studies have been commenced on the ecology of the common blowfly species other than *L. cuprina*. During the trapping studies described above, wild blowflies were trapped from other areas, carried to the centre of the trapping area, and liberated after marking with fluorescent lacquers and estimation of numbers. The percentage of marked flies retaken of the common nuisance species *Calliphora augur* indicates that this species occurs in far greater numbers than *L. cuprina.* Similar, though less conclusive, evidence was obtained for *C. stygia*. It was found that these two species of *Calliphora* have the power of extremely rapid dispersal.

Some information has also been obtained on other species attracted to carrion-baited traps. *Chrysomyia rufifacies* was found to have unsuspected powers of rapid dispersal, and specimens were taken three and a half to four miles from the centre of liberation in less than 24 hours. The smaller species *Microcalliphora varipes* disperses much more slowly. A very limited amount of data on the dispersal of the bushfly *Musca* *vetustissima* has been obtained indicating that the movement of the species is much more restricted than that of the *Calliphora* species. An important observation arising from the ecological studies, however, is that the Western Australian blowfly trap is a useful tool for the investigation of the ecology of *M. vetustissima,* up to 15,000 flies per day per trap being taken in some situations.

(*b*) *Life-history Studies of Blowflies.*—Studies of blowfly biology have been continued, and the breeding habits and life histories of further species elucidated.

(*c*) *Extension of Period of Protection against Body Strike.*—Final insectary tests on the persistency of DDT incorporated in the L.B.E. branding fluid base indicated that it had significantly greater persistency than that of a colloidal preparation.

4. INSECT PHYSIOLOGY AND TOXICOLOGY.

(Division of Entomology.)

(*a*) *Digestion of Wool by Insects.*—It is now well established that the three groups of keratin-digesting insects (clothes moths, carpet beetles, and chewing lice) are characterized by highly reducing midgut digestive secretions. When wool is digested the resistant disulphide bonds of keratin are reduced and proteolytic enzymes are then able to continue the degradation.

Cysteine desulphydrase, an enzyme responsible for the production of hydrogen sulphide from cysteine, has been investigated in some detail in insects. This enzyme is more active in the gut of the clothes moth larva than in any of the vertebrate sources (e.g. rat liver) so far reported. It is also present, but less active, in other insects including carpet beetle larvae. The presence of high desulphydrase activity in clothes moth larvae and of low activity in carpet beetle larvae appears to be correlated with the ability of the former, but not the latter, to eliminate metals as sulphides.

The pH optima of insect desulphydrases are higher than that of the rat liver enzyme. All are inhibited by arsenious oxide, phenylhydrazine, sodium chloride, and potassium nitrate in appropriate concentrations, whereas thiourea, sodium pyrophosphate, and sodium fluoride have little effect. There appear to be a number of differences between the rat liver enzyme and the insect enzymes (e.g. activation of clothes moth enzyme by potassium cyanide) and the insect enzymes are by no means a homogenous group.

(*b*) *Peritrophic Membrane.*—The food in the midgut of many insects is enclosed within a single or multilayered sheath, the peritrophic membrane, which is permeable to food-digesting enzymes diffusing in and to the products of digestion diffusing out.

There is a great deal of confusion in the literature on its presence or absence in various groups of insects and on the origin of the cells which produce it. A re-examination of these questions, with the help of a microadaptation of a method for detecting chitin (a characteristic component of the peritrophic membrane), leads to the conclusion that the ancestral midgut epithelium (of endodermal origin) possessed the capacity to secrete a chitinous membrane enveloping the food. This capacity has been lost in some insects and, in others, it has been restricted to a particular zone of the midgut.

Studies indicate that the peritrophic membrane is produced continuously and at a higher rate in fed than in starving insects. In some species of fly larvae the average production rate lies in the range 5–10 mm./hr. The fine structure of the peritrophic membrane of the cockroach and of several other insects has been examined with the electron microscope. In the species examined the membrane appears to be a complex structure of which the most characteristic and resistan component is a fibrillar network. A second componen is a layer closely associated with the fibrillar network consisting of unorganized fibrils embedded in a amorphous ground substance. In its most perfec form the fibrillar network possesses hexagona symmetry, consisting of three systems of paralle fibrillar strands placed at 60° to each other. Th diameter of the fine fibrils composing the strands i about 100 Å and there may be several in each strand The separate strands of a system of fibrils are abou 0.15-0.2μ apart. The fibrillar networks are wel adapted to the formation of tough sheets, not readil torn.

(*c*) *Insect Muscle Biochemistry.*—A study of th cell fractions of blowfly flight muscles has indicate that the Mg-activated apyrase is located in th sarcosomes which are believed by some to be gian mitochondria. Unsuccessful attempts have been mad to show the presence in the sarcosomes of purin nucleoside phosphorylases. Active preparations o mammalian actomyosin-free apyrase, to compare th extent of its dephosphorylation of ATP with tha caused by the insect enzyme, have been made fro European rabbits and less active ones from Australian bred rats, mice, and rabbits. It appears that tw phosphate groups are split off by apyrases from al sources, in contrast with the classical opinion that onl one group is hydrolyzed. Work is in progress on grass hopper and rabbit actomyosins to determine whethe there is a difference in their pH for optimum activity

(*d*) *Chitin Metabolism.*—The metabolic sources o chitin are under investigation. The course of enzymi degradation of chitin and chitin esters by a chitinas has been followed. The esters studied are those whic might occur in the biological system. *N*-acetyl-D-gluco samine and D-glucosamine have been isolated fro the degradation products.

(*e*) *Chitin-Protein Association in Insect Cuticle.*— There is good evidence that there is some kind of asso ciation between the chitin and protein component of insect cuticle. Work is in progress on the reaction which may occur between chitin, *N*-acetyl-D-gluco samine, and D-glucosamine on the one hand and pro teins on the other hand.

(*f*) *Precursors of Cuticular Protein.*—Work on th differences in the composition of the larval, prepupal and early pupal haemolymph of insects has been con tinued. Many modifications have been made to method for the quantitative analysis of amino acids b filter paper partition chromatography and an accurat and reliable method has now been developed.

(*g*) *Influence of Nutrition on Reproduction.*—It wa previously shown that suitable dietary protein an carbohydrate are both required by females of th Australian sheep blowfly (*Lucilia cuprina*) before the can mature eggs. Both classes of foodstuff can b obtained from aphid honeydew, but only carbohydrat from the coccid honeydews tested. Neither carbohydrate nor protein can be obtained in adequate quan tity from a wide variety of flowers.

The products of digestion of carbohydrates have bee determined by means of paper chromatography Enzymes splitting maltose, sucrose, trehalose, an melezitose have so far been detected in the salivar glands. Their presence and possible production in th adult midgut is being investigated. The natura carbohydrate diet of wild flies is also being investigated In one instance *L. cuprina* caught in a field where shee had been struck were shown to have obtained thei carbohydrate requirements from *Eucalyptus* blossom.

Sources, other than dead mammals, which migh serve to supply the protein requirements of female flie in the field are being examined. When the protein content of grass is high (spring and autumn), fresh shee oppings brought into the laboratory supply adequate otein for egg maturation. In summer, the protein ntent of the grass and of sheep faeces is low and es are unable to mature eggs with this as their only otein source. The faeces of sheep grazing on im- oved pastures (*Phalaris* and clover) provide a better pply of protein than faeces of sheep on natural grass.

5. Biological Control.

(Division of Entomology.)

(*a*) *St. John's Wort* (Hypericum pertoratum).—) *Ecological Studies at Bright, Victoria.*—Following on the intensive ecological study already undertaken the effect of *Chrysomela gemellata* Rossi and *C. perici* Forst. on St. John's wort in the Bright district, ctoria, periodic surveys are continuing of the main estation areas of the weed. Indications are that in eas of more equable climate than at Bright (i.e. newhat warmer and drier), the insects are capable more extensive defoliation of the weed in infested ests and plantations. As at Bright, the beetles show marked tendency to avoid densely timbered country. owever, the survival rates of offspring of the rela- ely few adults which reproduce in densely timbered eas appear to be higher than those observed around ight. This difference in survival is considered suffi- nt to account for the more extensive defoliation served in other places, owing to the fact that the ount of *Hypericum* foliage is low per unit area in ests, and comparatively few insects are therefore eded to bring about complete defoliation of their host nt.

In the Bright district the total treeless area in which *ypericum* is being controlled at a low density by e beetles, notably *C. gemellata,* appears to have in- eased considerably during the last two years. (This ea is composed of sites in the immediate vicinity of rt-infested forests, &c., which act as a damping factor population fluctuation enabling the insects to persist moderate numbers.) The area reclaimed from *ypericum* by a combination of beetle attacks and sture improvement, or by the latter alone, has also reased. Very little infested farmland now remains re. In the adjoining Myrtleford and Mudgegonga tricts, the beetles have recently caused spectacular d extensive destruction to *Hypericum* stands in par- lly or wholly cleared farmland in the same manner during the period of rapid multiplication in the ight district some years ago.

(ii) *Distribution of* Chrysomela *species.*—New erations made in the year 1952-53 were much less an in previous years. Some 300,000 insects, mostly *gemellata,* were collected in the Myrtleford district Victoria. Half of these were sent to Western Aus- lia at the request of the Government Entomologist, o arranged for their release at Forest Grove and eenbushes. The remaining 150,000 beetles were erated in New South Wales, at Burrinjuck to replace colony destroyed by fire, and in the Tuena, Rylstone, d Capertee districts.

The beetles are reported to be making good progress the Orange, Sodwalls, and Rylstone districts, some ductions in density of the weed being evident in the rmer two. Liberations appear to have failed in the pertee and Cullen Bullen areas.

(iii) *Introduction of* Zeuxidiplosis giardi.—This cidomyid gall fly has again been introduced from lifornia, and this time a laboratory colony has been ccessfully established. The flies are now in the second neration and liberations in the field will be made as on as conditions are favorable.

(*b*) *Other Weed Problems.*—(i) *Crofton Weed* (Eupatorium glandulosum).—The Queensland Department of Lands has made host restriction tests in Hawaii upon *Procecidochares utilis,* a gall-forming Tephrited which was introduced from Mexico into Hawaii, where it has had a marked effect on the abundance of Crofton weed. The Division assisted in designing the test programme and recommended an importation permit after the tests were completed. The insect was subsequently introduced and established by the Department of Lands.

(ii) *Lantana* (Lantana camara).—It is expected that Australia will participate in the Hawaiian co-operative investigation (in the Central America region) into the natural enemies of lantana. The present plan is for a Queensland Department of Lands entomologist (financed by the Commonwealth and Queensland) to participate as associate explorer, but insect introductions will not be made until a later stage when the risks involved in the introductions can be more fully assessed.

(iii) *Noogoora Burr* (Xanthium pungens).—Renewed attempts for the biological control of this weed are being considered in view of its importance and the expressed desire of Queensland authorities that this should be done. No final decision has been made.

(*c*) *Insect Problems.*—(i) *Cabbage Moth* (Plutella maculipennis).—Consignments and liberations of *Diadromus collaris* (Italian strain), *Angitia tibialis,* and *Apanteles plutellae* have continued. The work of introduction and establishment of parasites against *Plutella* is, however, drawing to a close. A complex of the most important foreign parasites of this insect has been introduced, recoveries of virtually all of them have been made, and, where field examinations have been made, the percentage parasitism attained is very high indeed. *Angitia cerophaga* appears so far to be the most important of the established parasites. There seems to be no doubt that *Plutella* has declined markedly in abundance since these parasite introductions were begun.

(ii) *Cabbage White Butterfly* (Pieris rapae).—No further work on parasite introduction is contemplated so far as this host is concerned, and no further liberations of *Apanteles rubecula* were made. This parasite has been recovered quite frequently in the field and is probably permanently established in Australia. Field observations indicate that *P. rapae* is very heavily parasitized by the introduced *A. glomeratus* and *Pteromalus puparum,* virtually 100 per cent. parasitism being common.

(iii) *Green Vegetable Bug* (Nezara viridula).—Increasing attention is now being paid to the biological control of this species. The importance of *Nezara* differs considerably in different parts of Australia, partly for climatic reasons and partly because of variation in different areas in the efficacy of the introduced egg-parasite *Microphanurus basalis.* In general this parasite has been quite effective, but *Nezara* remains an important pest in some regions.

During the current year four parasitic enemies of *Nezara* have been introduced. These are: *Trichopoda pennipes,* a parasite of adult *Nezara* from Florida; *T. pilipes,* a related species of similar habit from the West Indies; an egg-parasite from the West Indies, *Ooencyrtus submetallicus*; and a West Indian strain of *M. basalis*—the parasite already established here.

Experience has shown that the *Trichopoda* spp. are too difficult to culture in quantity; consequently, these have been liberated in the field in New South Wales and Queensland. Recoveries of *Trichopoda* have been made already, but it is too early to know if either of the species is permanently established. The two egg-parasites are being cultured in the laboratory and distribution throughout Australia was begun during the year and will be continued next season.

(iv) *Queensland Fruit Fly* (Dacus tryoni).—In the newly established Sydney laboratory work has continued in the attempt to introduce parasites of the fruit fly, involving development of a mass culturing technique and tests to determine whether imported Opiine parasites of the oriental fruit fly (*D. dorsalis*) can parasitize the Queensland fruit fly.

Work on mass culturing has shown that fruit flies can be reared from fruit which has been in cold store; this greatly facilitates the supply of rearing material. Other experiments have been made to determine the best methods of rearing puparia, and of obtaining eggs without the necessity of having them deposited in fruit. Previously the necessary protein supplement to the diet of adult flies to enable them to produce eggs was only available from the United States. A local food product has now been used successfully for this purpose.

A consignment of *D. dorsalis* parasites, consisting of *Opius longicaudatus* (Ashmead) and *O. thaiensis*, was received from Honolulu in April, 1953. Both species have been reared through to the F_2 generation on *D. tryoni* material. *O. thaiensis* successfully parasitized *D. tryoni* larvae under two different sets of insectary conditions; because of small numbers, *O. longicaudatus* has not been so fully tested as the other species.

(v) *Potato Tuber Moth* (Gnorimoschema operculella).—Various parasites of this important pest were introduced and liberated some years ago. A field survey has begun to determine whether any of those parasites are established. Early results are not very promising, but parasitized specimens found in the field may include some parasitized by *Copidosoma koehleri*.

(vi) *Red Scale* (Aonidiella aurantii).—A reliable report has been received that the red-scale parasite *Comperiella bifasciata*, introduced from California several years ago, has been recovered during two successive seasons at Mildura, Victoria. This parasite has been known for some time to be established in South Australia.

(*d*) *Other Hosts*.—Preliminary inquiries have been made in regard to the parasites of several other important insect pests. These include *Ceroplastes destructor* (white wax scale), *Ceroplastes rubens* (pink wax scale), and *Listroderes obliquus* (brown vegetable weevil). These inquiries indicate that the biological control of these important species should be undertaken as soon as staff and other matters permit.

6. Population Dynamics.

(Division of Entomology.)

Investigations aimed at finding how populations accommodate themselves to external stresses, such as applications of insecticides, have been continued, using the sheep blowfly, *Lucilia cuprina*, as the experimental subject. It has been found that, although the immediate effect of destructive factors is to reduce density, compensatory reactions are set up which tend to reduce, and sometimes even reverse, this effect when the populations readjust themselves to the continued operation of the destructive factor. For example, in one experiment 50 per cent. of the whole adult population of flies was destroyed every second day over a period of ten months; the compensatory reaction caused the number of flies emerging each day to be much greater and the average density of flies to be only a little less than in an otherwise similar experiment in which there was no imposed destruction. In other experiments it was found that, when 99 per cent. of all emerging flies were destroyed, the adult popu tion, instead of being reduced to 1 per cent., was o reduced to 10 per cent., the number of flies emerg per day being apparently six times as great, and average life span of the adults twice as long as the control population in which no destruction imposed. Similar compensatory reactions w observed in many other experiments in which differ kinds of situations were studied and the vari mechanisms of compensation were clearly revealed. is clear that populations can adjust themselves to v great external stresses, and that the resultant popu tion densities are far from being directly related the favourability or otherwise of the environment.

Largely as a result of these population experimen a revised system of classification of environmen factors according to the influence they have upon po lations has been evolved, and further advances h been made in the classification of the basic syste of population growth and maintenance, twelve s systems now being recognized.

7. Field Population Studies.

(Division of Entomology.)

Recently the Division began long-term field stud on insect populations. The work is a logical a necessary extension of the theoretical and laborat studies in progress on population dynamics, and aimed at determining the factors responsible governance of the numbers of different kinds of inse under natural conditions. It is becoming increasin evident that a knowledge of such factors is essent for the successful control of many pests.

It is planned to concentrate first on species subjec to a minimum of human interference in order to li the complexities of a very difficult problem. If investigations on such species are successful, it intended to extend the work to various pests at prese attacked by insecticides.

Four species of Psyllidae and two of Coccidae ha been chosen for study. Of these, three species so times develop enormous numbers, thereby caus severe damage to eucalypts. Our present limi knowledge suggests that the others rarely, if ev develop very high numbers, although considera fluctuations in population density occur both in sp and in time.

By suitably arranged field observations, a number factors have been examined in a preliminary way reaction to density changes on the part of the two m destructive psyllid species, i.e. examined as possi governing factors of population density. The resu suggest that both species normally depend on natu enemies for density governance. Efforts are now bei made to ascertain which of their natural enem possess the necessary property of density reaction. T data obtained suggest that, under some conditions least, none of their numerous encyrtid parasites density-reactive. Of the other predators, Syrphid the larvae of which feed on psyllid nymphs, appear possess this property in a special form. It seems th adult female syrphids concentrate their ovipositi and consequently their larval stages, in places wh the psyllids are most numerous, thus tending to bri psyllid numbers down when and where they beco abundant.

It will be necessary to continue observations many more generations of psyllids before conclus evidence can be obtained on the density-governi powers of both the syrphids and their other natu enemies.

Work on the other four subject species has been nited to determining their natural enemies, about hich little or nothing is known.

8. Locust and Grasshopper Investigations.

(Division of Entomology.)

In the 1951-52 Annual Report it was stated that the pulation of the Australian plague locust (*Chortoi-tes terminifera*) has fallen to such a low level in the ogan-Macquarie outbreak area that swarm foundaon in at least the southern portion of that area could ot be expected for some years unless re-population ok place from outside. In the spring of 1952-53 the pulation was still at the very low level of the previous tumn in the vicinity of the Trangie research station. y February, however, rather higher densities were ted in this general area, but nobody was prepared r the widespread appearances of swarms in March d April, which seem to herald the commencement another outbreak of *Chortoicetes* after several years quiescence. The origin of these swarms has not en established, but suspicion centres on the drier stern portion of the outbreak area, which may well ve obtained crucial additions to their local populaon from other outbreak areas further to the west and rth-west. The experience of the last few months derlines the crucial importance of instituting an equate patrol service to cover all outbreak areas, so at local multiplication in any danger area will not ss unnoticed.

The effect of the new outbreak upon the ecological ntrol experiments at Trangie can only be unfortute. The barriers of *Atriplex nummularia* had ached the stage where their effect on the local ultiplication of locusts could be studied as soon as a gnificant population of locusts had developed. All e barrier plots have now been invaded by flying arms entering from outside, and egg-laying has ken place in some of them. The local populations both barrier plots and control areas have thus been ossly disturbed. It will not be possible to evaluate e situation until the spring, but it is highly probable at tests will now have to be postponed for a considerle period.

Recording work on the development of the barriers, d in connexion with the experimental revegetation "scalds", as a possible means of reducing the extent the oviposition habitat in an outbreak area, has been ntinued.

Taxonomic work on locusts and grasshoppers has en continued. Increasingly large collections have en reaching the Division of Entomology Museum om all parts of Australia.

9. Cockchafer Investigations.

(Division of Entomology.)

General taxonomy of miscellaneous scarab species as continued. Trapping records were maintained om September to April.

Rearing work enabled further correlations to be ade between larval types and identified adult material. urther studies are in progress on the effect on *phodius howitti* of climatic factors of natural soilrne diseases.

10. Red-legged Earth Mite Investigations.

(*a*) *Control in the Field with DDT.*—Evidence has dicated that sheep grazing on the dry pastures treated ith DDT adversely affected the residual qualities the DDT, probably by burying much of it beneath the soil surface out of reach of the mite.

The general conclusion to be drawn from all the field experiments with DDT is that a very satisfactory control of the earth mite can be achieved by proper application. Generally speaking, late summer treatments have been unsatisfactory and, where possible, the insecticide, either in dust or spray form, should be applied immediately after the first mites hatch from the oversummering eggs. Where it is not possible to get machinery on to the land because of wet conditions, aircraft can be employed with equally good results. The recommended rate of application is ½ lb./acre of *pp′*-DDT.

(*b*) *Experiments with Other Insecticides.*—Further observations on small plots have indicated that parathion, chlordane, and aldrin are not effective against the earth mite, whereas dieldrin has an effect approaching closely that of DDT. The latter, however, is still the outstanding insecticide. A field experiment is now being conducted with dieldrin.

(*c*) *Effect of the Mite on Pasture Production.*—This experiment has now been running for two complete seasons. The results in the second year closely follow those of the first year and there has been no indication as yet of any marked cumulative effect of mite attack. In the first year, eradication of the mite by DDT treatment resulted in a 63 per cent. increase in subterranean clover yield, a 32 per cent. increase in grasses, a 21 per cent. increase in *Erodium*, a 12 per cent. decrease in capeweed, and a 9 per cent. increase in total yield. The increase in subterranean clover was highly significant and the increase in total yield was also significant. In the second year the mite-free areas showed an increase in subterranean clover yield of 55 per cent., a 28 per cent. increase in grasses, a 19 per cent. increase in *Erodium*, a 35 per cent. decrease in capeweed, and a 17 per cent. increase in total yield. The increase in subterranean clover yield was again highly significant. The increase in grass yield was significant, as was also the decrease in capeweed.

The experiment is being continued.

11. Lucerne Flea Investigations.

(Division of Entomology.)

(*a*) *Control in the Field.*—Following the highly successful experiments in 1952, parathion can now be recommended for the control of this pest. Applications at rates as low as ⅛ pint/acre of 20 per cent. emulsion —by means of a low-volume boom spray—achieved almost 100 per cent. kill of lucerne fleas present at the time of treatment. However, this insecticide has little or no residual effect at this concentration, and any eggs present during spraying will later hatch without interference and initiate a fresh infestation. Ideally, therefore, treatment should be carried out early in the season after all oversummering eggs have hatched and before any second-generation eggs have been laid. If this cannot be done, two treatments may be necessary. This insecticide is highly toxic to stock and to humans, and great care must be exercised in its use. However, owing to the very small amount which is applied, there is practically no danger to grazing stock, which can be reintroduced into the paddock within a week or possibly earlier.

Parathion alone will not achieve an adequate control of the earth mite, should this pest also be present, but the addition of 1 pint/acre of 20 per cent. DDT emulsion will ensure the control of both pests.

(*b*) *Lucerne Flea-Bdellid Mite Ecology.*—Two areas have been chosen and pegged out this year for a study of the relation between the lucerne flea and its predator, the bdellid mite. The earth mite will also be included in these observations and interactions between the three groups investigated. It is proposed also to map the distribution of the bdeddid mite species over as wide an area as possible.

Life-history studies of both lucerne fleas and bdellid mites will be carried out where possible.

12. Insects and Viruses.

(Division of Entomology.)

(*a*) *Viruses Attacking Insects.*—A new virus disease of a pasture caterpillar *Pterolocera amplicornis* has been found in the vicinity of Canberra. This virus causes the formation of "polyhedra" in the fat-body and other tissues of the larva, and electron micrographs taken at the Division of Industrial Chemistry have revealed the virus particles within the polyhedra. Similar viruses attacking insects in Canada and the United States of America have been used successfully for insect control; it is hoped that further work will permit their evaluation in insect control under Australian conditions.

(*b*) *Viruses Affecting Plants.*—Further data have been obtained about the transmission of rugose leaf curl, the name proposed for the new disease of carrot, tomato, lucerne, and other plants, previously reported. The leafhopper vector of this virus, *Austroagallia torrida* Evans (previously placed in the genus *Nehela*) is widespread in Australia, but is thought to be an introduced species. The virus is transmitted by a female leafhopper to about 40 per cent. of her progeny. This attribute of transovarial infection is very unusual, and has only been recorded previously for three other viruses.

Rugose leaf curl has been transmitted either by *A. torrida* or by grafting to sixteen species of plants belonging to eight families. No symptoms could be detected on potato, egg plant, pepper, silver beet, or wild sage. The virus was first isolated from *A. torrida* collected in the vicinity of Canberra. A second isolation has now been made from insects collected from Hawkesbury, New South Wales. A virus-free leafhopper colony has not so far been obtained. Several colonies, thought to be virus-free, produced no symptoms on indicator plants on which they fed, but their progeny produced the disease without access to viruliferous plants.

(*c*) *Transmission of Myxomatosis and Related Viruses.*—Tests in collaboration with the Australian National University have now shown that cowpox in rabbits, ectromelia in mice, and fibroma in rabbits can be transmitted by mosquitoes. Similarly, transmission by mosquitoes under laboratory conditions of myxoma mutants has been demonstrated, and is now being studied extensively. Preliminary indications are that certain mutants of myxoma are less likely to spread under field conditions than the more virulent parent strain.

(*d*) *Physiology of Virus Vectors.*—Two projects have been studied. One, concerned with the mechanism by which aphids transmit plant viruses, has involved an examination of the effects of starvation on aphid physiology. Periods of starvation of 24 hours did not appear to affect the production of saliva, the rate of penetration of stylets into plant tissues, the production of digestive enzymes, or the amount of material ingested. Starvation for 24 hours did, however, influence the behaviour of the insects to an extent that is probably sufficient to account for the effects of starvation on virus transmission.

The second problem arose from reports on changes in vector efficiency following wounding of the midgut. Nothing was known of the other effects of such gut wounds or the rate of healing of these wounds. comparative study of the healing of gut wounds ha shown that, in a leafhopper and a mosquito, healin takes place slowly by comparison with the process i the cockroach; several interesting differences in th mechanisms by which healing occurs have been reveale

13. Termite Investigations.

(Division of Entomology.)

Testing of the relative resistance of timbers ar constructional materials has continued, using th standard laboratory testing technique. Altogether 51 test colonies were installed, comprising 490 *Nasutitermes exitiosus* and 22 of *Coptotermes lacteu* The reduced number of test colonies compared with th previous year was due largely to difficulties in obtai ing some of the test samples of various commerci timbers. Work was continued in attempting to develo a standard laboratory colony technique for *Mastoterm darwiniensis.*

The more important test results were (1) the additio of a low percentage of pentachlorophenol to a local manufactured hardboard produced a board with hig resistance to termite attack, (2) the order of decreasin resistance of six commercial timbers (based on tests 50 trees of each species) was *Syncarpia laurifoli Eucalyptus crebra, E. tereticornis, E. paniculata, micrantha, E. grandis.*

The normal inspection and maintenance of field tes of timbers and preservative treatments around mou colonies of *N. exitiosus* and *C. lacteus* were carri out. The annual examination of soil poisoning tes showed that both creosote and 5 per cent. pentachlor phenol (both used at the rate of 0.5 gal./cu. ft. soil which had given complete protection against *exitiosus* attack for four years, began to break down the fifth year. Five per cent. sodium pentachlor phenate and 10 per cent. sodium arsenite have ea given complete protection for four years and 5 per ce DDT for three years.

In similar tests against *C. lacteus,* 5 per cent. DD 5 per cent. pentachlorophenol, and creosote have given complete protection for at least two yea Additional soil tests including creosote, 5 per ce DDT, 5 per cent. pentachlorophenol, 5 per cent. sodiu pentachlorophenate, and 2 per cent. chlordane ha been installed in the Riverina, where attack may be d to *Coptotermes frenchi, C. acinaciformis,* or *Schedo hinotermes reticulatus.*

Approximately 720 series of termites were receiv for identification during the past year.

14. Ant Investigations.

(Division of Entomology.)

(*a*) *Argentine Ant.*—A conference of entomologi was convened at the request of the Agricultural Coun and held in Canberra on 24th and 25th June, 1952, consider the possibility of eradication in large are The conference agreed that it had been found possi to clear experimental areas of Argentine ants relatively small cost; and to provide more conclus evidence it recommended that a large-scale eradicati campaign be carried out in Sydney where the infest area was estimated to be only 1½ square miles. Follo ing discussions between the Commonwealth and N South Wales Governments, agreement was reach early in November that the State and the local gove ment bodies affected by the ant would bear the cost the campaign and the Commonwealth would ma available the Organization's technicians and equipm to work in co-operation with State entomologists.

From previous experiments it was considered th one application of 60 gal./acre of 2 per cent. chlorda spray, applied by trained labour, would remove mediate danger and possibly eradicate the pest from e Sydney area. It was envisaged that some spot eatment would be necessary as a follow-up treatment r eradication.

The first step in the treatment was to spray around l infested areas to prevent the Argentine ant spread- g while the general treatment was in progress. A tal of 1,627 gallons of spray was used on the border eatments. The intensive treatment began at Lid- mbe, New South Wales, on 15th December, 1952. pray operators were recruited from Sydney University udents who were on long vacation. During the mmer of 1952-53 additional infested areas were und and 41 separate infestations totalling 2½ square iles had been surveyed by June, 1953. The infesta- ons were as far apart as Rosehill, Maroubra, Miller's oint, and George's River, threatening an area of over 0 square miles of city and suburban properties south the Parramatta River.

The total area sprayed from 15th December, 1952, til the work closed down for the winter on 8th June, 53, was 1,161 acres. A total of 73,040 gallons of per cent. chlordane spray was applied, an average of .8 gal./acre. The amount of spray applied and the ethod of application varied from suburb to suburb.

An area of approximately 300 acres remained sprayed when the work closed down for the winter.

Experiments in co-operation with the Western Aus- alian Departments of Agriculture and Health were ntinued during the year; in Albany, applications of per cent. chlordane spray to strips of Taylorina *Psoralea pinnata* L.) swamp failed to eradicate the rgentine ant. An examination of the area was made d it was found that within the dense growth of aylorina the Argentine ants do not trail to the same tent as in areas where trees are less dense.

A comparative test of sprays containing 0.5 and 1.0 r cent. aldrin, 0.5 and 1.0 per cent. dieldrin, 2 per nt. chlordane, and 2 per cent. DDT was begun in arch, 1953, at Shenton Park, Western Australia. hree replications of each of the six treatments were rayed, each plot being six house blocks. Examina- ons one and two months after treatment suggest that eldrin and aldrin may prove just as effective as lordane, at a lower concentration.

An experiment begun at Shenton Park, Western ustralia, in December, 1951, has shown that sprays ntaining 2 per cent. dieldrin at the rate of 50 l./acre completely controlled the Argentine ants ithin the treated area and for at least fifteen months evented the establishment of nests in the treated ocks by ants from neighbouring areas.

(*b*) *Meat Ants.*—The series of colonies of the meat t (*Iridomyrmex detectus* Sm.) treated in the summer 1951-52 with dusts containing 2 per cent. DDT, 2 r cent. chlordane, 2 per cent. aldrin, and 2 per cent. eldrin at a standard rate of ½ oz. dust to each entrance le were kept under observations during the summer 1952-53.

DDT dust reduced the population after treatment, t ants were present in all nests and populations creased with time. The DDT treatments were gnificantly inferior to the chlordane, aldrin, and eldrin. The nests treated with chlordane and aldrin ere still free of ants eighteen months after treatment, spite attempts to repopulate the treated nest sites by ts from neighbouring colonies; the nest site of one of e four treated with dieldrin dust was occupied by a all invading colony fifteen months later.

The development of incipient colonies of the eat ant was again studied after a spring nuptial ght on 29th October, 1952. One hundred and fifty tes were pegged and colonies were dug out at regular tervals to study brood development. The incipient colonies of this series followed the same pattern as a previous series studied after a spring flight in 1951, but workers occurred earlier. The first workers were found at 77 days and the first entrance holes to be opened up were noted at 97 days after the nuptial flight. During the summer months there was again a high mortality of the females founding colonies.

(*c*) *Harvester Ants affecting Germination of Forest Trees.*—Ants of several genera in Australia, chiefly *Pheidole*, *Monomorium*, *Meranoplus*, and *Melophorus*, collect seeds for food and in some areas they do much to prevent the germination of seeds of forest trees. In addition, other species of ants collect fruits of trees for nest building and mechanically affect germination.

In co-operation with the Australian Forestry School, a preliminary experiment has been carried out to study the effect of a 2 per cent. chlordane cover spray on the germination of seeds of eucalypts. However, conditions were unusually favourable for seed germination, and the results were inconclusive.

15. CATERPILLARS OF PASTURES AND FIELD CROPS.

(Division of Entomology.)

Studies have been continued on the identity, distribution, and seasonal occurrence of several injurious cutworms and armyworms (Noctuidae) in Australia. It has been established that two species of *Heliothis* have previously been confused in Australia with *H. armigera*, a pest of vegetables and field crops hitherto believed to have a world-wide distribution. In this country *H. armigera* appears to be confined to the coastal and sub-coastal areas of New South Wales and Queensland and possibly also to the northern part of the Northern Territory. An indigenous species, *H. punctigera*, occurs throughout the Commonwealth, with the possible exception of coastal Queensland north of Rockhampton. Where it occurs, *H. armigera* is an important pest of tomatoes, maize, tobacco, and cotton each year. Outstanding attacks by *H. punctigera* are less frequent but it is the major insect pest of linseed, and also causes severe losses in tomato, tobacco, pea, and lucerne crops. There are also numerous reports of attacks on stone and pome fruits in the Murrumbidgee Irrigation Area, and in South and Western Australia.

In southern Australia, armyworm outbreaks in pastures and field crops have usually been ascribed to *Persectania ewingii*, which has also been regarded as the main armyworm pest in New Zealand. A study of the identity and distribution of *P. ewingii* has shown that two species, which differ considerably in their ecology, occur in southern Australia and are probably both responsible for damage to pasture and cereal crops. *P. ewingii* alone occurs in Tasmania where serious attacks on cereal crops have frequently been reported. There it causes most concern in the summer months. In southern Victoria severe outbreaks also occurred in December, 1952. Although late winter attacks in the Riverina and north-western Victoria were apparently due principally to this species, outbreaks of a second undescribed species of *Persectania* at times occur in this area. The latter species appears to be the more important armyworm in Western Australia, attacking crops in the wheat belt. Neither of these species are believed to occur in New Zealand, where a native species *P. aversa* has previously been confused with *P. ewingii*.

Three important cutworms are responsible for damage to pastures and field crops in eastern Australia. In Queensland the more important species appear to be *Euxoa radians* and *Agrotis ypsilon*. Both of these are also injurious in New South Wales. Damage by *A. ypsilon* is probably largely confined to the coastal areas north of Sydney. *E. radians* and another species, *A. infusa*, are much more widely distributed in this State but, whereas the former is usually a pest in the late spring and summer months, outbreaks of the latter occur in late winter and early spring. In 1952 larvae of *A. infusa* were widespread in winter pastures on the tablelands, the western slopes, and in the Riverina where they fed on *Medicago* spp. and annual composites. In northern New South Wales and on the Darling Downs linseed crops were severely attacked in late winter. The resulting adults were very numerous and large southerly migrations of the moths occurred in the spring and early summer in southern New South Wales and Victoria. During migration the moths were conspicuous even in the daytime feeding at *Eucalyptus* and other blossoms. As in the previous two summers, immense numbers of the moths migrated to the mountains of south-eastern New South Wales and western Victoria to aestivate gregariously in crevices and small caves in certain extensive rock outcrops.

Observations during the summer on such assemblages of *A. infusa* moths at an altitude of 6,000 feet in the Australian Capital Territory have shown that spring migration and aestivation is an annual event. A small proportion of the moths become intensely active just after sunset and just before sunrise, when a randomized flight over the tops of the rock outcrop occurs. During these flights sugary food is not normally sought. None of the moths copulate until aestivation is completed, the ovaries remaining in an immature state. This year migration in a northerly direction from these camps had begun in February and continued until early April, when the largest movements to the north and west were observed and the aestivating populations completely dispersed.

It has been concluded that this habit of spring migration and gregarious aestivation, culminating in a return migration to the breeding ground in the autumn, serves an important function in the ecology of *A. infusa*. The dicotyledon food plants of the larvae grow profusely in the winter months when favourable rains occur. In the summer perennial grasses, which do not provide suitable food, are normally dominant on the heavy grey clay soils favoured by the larvae. As the high summer temperatures of the breeding areas do not permit adult aestivation, the migratory habit has apparently arisen as an adaptation to these unfavourable conditions. The relatively low temperatures and high humidities of the aestivation shelters permit the moths emerging in the spring to live during the summer months and reinfest their breeding grounds in the autumn.

16. INSECT PESTS OF STORED PRODUCTS.

(Division of Entomology.)

When grain is stored under hermetic conditions any insect pests present are controlled by a change in the proportion of the main constituents of the intergranular air. Oxygen is used up and carbon dioxide produced by the insects until respiration is no longer possible. In order to study the effect of these gases, and to arrive at a closer understanding of the events that occur in the field, equipment has been built to provide continuous streams of any desired mixtures of nitrogen, oxygen, and carbon dioxide.

Exposing grain pests to these mixtures has enabled the separate and combined effects of these to be determined. Using grain weevils, *Calandra granaria* L., as test insects, it has been shown that, under otherwise optimum conditions, concentrations of carbon dioxide in excess of 30 per cent. or oxygen concentrations below 2 per cent. are necessary to kill the insects.

Some progress has been made towards the development of an insect-proof packing material. Very finely divided hard minerals bonded to a paper backing with a plastic adhesive have proved resistant to termites in
the laboratory. The termite *Nasutitermes exitiosu*
(Hill) was used in "penetrate or starve" tests owin
to its availability.

Tests on the effects of radio-frequency fields o
insects showed that the method was successful on
small scale, but that it would be economically usefu
for only a specialized range of commodities.

17. INSECTICIDE INVESTIGATIONS.

(Division of Entomology.)

The new insecticides, as well as the old, are effectiv
in controlling certain species of insects, but relativel
ineffective against others. There is abundant evidenc
for this specificity of action, which is often exploite
in controlling pest species with materials harmless t
beneficial ones, but comparatively little is known of th
underlying reasons why some species are susceptib
and others resistant. This indicates the need fo
intensive study of the factors determining the su
ceptibility of insects to chemical control measures. Th
need has been emphasized during the last few years b
the development, in various countries, of insecticid
resistant strains of certain species.

During the year further environmental and bioti
factors have been studied in the housefly-DDT systen
Using modified testing precedures, which take int
account the sex and body weight of the test insects,
has been possible to trace the variation in susceptibilit
to DDT which accompanies aging of the insects, and t
study the effect of the age of the parents on th
susceptibility of their progeny. Some further aspec
of the testing procedure, such as the use of anaesthetic
to facilitate the handling of the insects and the temp
erature to which the insects are exposed during an
after dosing, have also been examined for their effec
on the insects' response to insecticide treatment. Th
stage has been reached, in the study of this systen
where each of the controllable factors likely to increas
the variability of response has been evaluated in
dependently and there is evidence of increased precisio
in the testing method. A detailed study of the exac
nature of the dosage-response curves is in progress.

18. OTHER INVESTIGATIONS.

(Division of Entomology.)

(*a*) *Entomological Survey of Cocos Islands.*—Th
survey was carried out at the request of the Departme
of Civil Aviation to obtain information about th
insects occurring on the Cocos-Keeling Islands befo
the new air route from South Africa was opened t
ensure that both plant and animal quarantine measur
on this route were effective. Some 2,000 specime
were collected from the several islands in the grou
A study of these has shown that the majority of th
species represented already occur in Australia. Tw
notable exceptions are the rhinocerus beetle, *Oryct*
rhinocerus (a serious pest of coco-nuts), and *Agril*
marmoreus, a small buprestid beetle which attac
citrus in Malaya and Indonesia.

Aedes (Stegomyia) albopictus, which is capable
transmitting dengue fever, filariasis, Japanese
encephalitis, and yellow fever, is the more common
the two mosquitoes on the islands; it is also present i
the northern part of Australia. There is no evidenc
however, that any of the diseases mentioned are prese
in the Cocos Islands.

The report of the survey has been issued for restricte
distribution by the Department of Civil Aviation a
"Aviation Medicine Memorandum No. 14—Entom
logical Survey of Cocos-Keeling Islands" by T. G
Campbell.

(*b*) Lyctus (*Powder-post Beetle*) *Investigations.*—
Work has continued on the rearing of *Lyctus* larvae o
a synthetic food medium. The most important finding
have been: (1) sucrose in the diet may be replace

isfactorily by a number of other sugars such as xtrose, laevulose, maltose, mannose, xylose, raffinose;) larvae may be reared successfully if starch in the t is replaced by amylose; (3) the total methanol ract of either *Melicope australasica* or *Cryptocarya ucescens* (two resistant species) is toxic to *Lyctus* vae when added to the synthetic diet; (4) the testing various fractions of these extracts has not yet ealed the toxic principle.

n co-operation with the Division of Forest Products urvey is being made of the *Lyctus* susceptibility of a mber of Queensland timbers. At present, samples of re than 30 timber species are in test (*see* Chapter V, Section 6 (*h*)).

(c) *Export of* Leis conformis *to Egypt*.—The yptian Ministry of Agriculture requested supplies this beneficial coccinellid, and two consignments re forwarded by air in October and November, 1952. is understood that a laboratory colony has been ablished in Egypt from these consignments.

19. TAXONOMY.

(Division of Entomology.)

Work has continued on the Chalcidoidea, the largest oup of parasitic wasps. It must continue for many ars but, after the classification of the whole supernily has been considered, it should be possible to ise individual families.

Further progress has been made on the Diptera ies), and work on the taxonomy of the Calliphoridae, important group of blowflies, has been intensified. revision of the Nemestrinidae is in press and a ision of the Apioceridae is almost ready for publican.

The Australian locusts and grasshoppers are being ised by an authority on the group in the United ates of America. The second volume of this comehensive work is now in press.

Taxonomic work has been done in certain groups of Lepidoptera, in particular the genus *Heliothis*. her families being studied are the Blattidae (cockaches) and certain of the Hemiptera (bugs).

X. WILD LIFE.

1. GENERAL.

Early in 1949 the Organization's Wild Life Survey ction was established to undertake a study of the history, habits, and general ecology of native or roduced mammals and birds that were of importance Australia by virtue of the fact that they were onomic pests. It was, however, in due course, also develop an active interest in animals which were neficial, calling for conservation and encouragement d not eradication and control.

Wildlife Survey Section.—As in previous years, greater part of the Section's activities has been ncentrated on the problem of the rabbit, and particurly on the virus disease, myxomatosis, and its epimiology. During the past year, however, it was nsidered desirable to resume work on certain lines of lirect" control, to which preliminary attention had en given during the early years of the Section but ich were discontinued in 1951 owing to the calls of myxomatosis investigations. One reason for this cision was a recognition of the limitations of myxoatosis, which even in favoured areas needs to be cked up and followed up by conventional methods rabbit destruction.

In furtherance of the aim of extending the Section's vestigations to animals which are beneficial to the ricultural economy, a start has been made in the idy of the ibis.

2. RABBIT INVESTIGATIONS.

(Wildlife Survey Section.)

(*a*) *Myxomatosis*.—For a period of twelve to eighteen months after December, 1950, when myxomatosis broke out in epidemic form in south-eastern Australia, the primary need was for a definition of the broad picture of its spread. This called mainly for extensive surveys, during the course of which much valuable, if circumstantial, evidence was obtained on the insects responsible for transmission of the disease in the field and other factors having an important bearing on the general epidemiological picture. During 1952-53 the emphasis was shifted from extensive survey work to more intensive studies on special aspects of the myxomatosis problem.

In areas which had benefited by high kills during the summer of 1951-52, as elsewhere, rabbit populations were built up as a result of breeding. During 1952-53 myxomatosis accounted for more than this increase, and in addition, the disease spread and performed well in areas where it had not been in evidence previously. As a result of this, the rabbit situation in the four mainland States (Queensland, New South Wales, Victoria, and South Australia) is more satisfactory than at any time within living memory. The generally low level of rabbit infestation has enabled the pastures and crops to respond to, and the stock to take advantage of, the favourable season, which has been reflected significantly in the country's wool clip and wheat harvest. The decrease of rabbit damage to crops has been particularly noticeable in the Mallee, where many indirect effects of low rabbit numbers have been noticed, e.g. time, labour and finance normally directed to rabbit control have been available for constructive work on properties. The production figures of a dairy farm in the Murray Valley, where the state of the pastures and the degree of rabbit infestation have been kept under continual observation for a three-year period, have shown that butterfat production has been doubled since the elimination of rabbits, brought about by myxomatosis and energetic follow-up measures by the landholder. In Western Australia and Tasmania the performance of myxomatosis has so far been rather disappointing, though useful local kills have been recorded. In view of the vigorous and widespread "seeding" of the virus by the State authorities, this must be accepted as a reflection of a relatively unsatisfactory insect vector position; but the experience in other States of the Commonwealth suggests that it is by no means impossible that the disease might make a useful showing during certain years.

During 1951-52, the first indications were obtained that some sort of adjustment between the host (rabbit) and parasite (virus) was taking place in the field. During the past year, although it has no significant effect on the overall very satisfactory situation, this process of adjustment had obviously made a considerable advance. Rabbits that had recovered from the disease appeared in many districts in numbers sufficient to excite comment; and in three or four areas where special investigations were carried out evidence of a markedly reduced case-mortality rate was obtained (*see below*).

Work on the insect vectors of myxomatosis has been carried out in the Murray Valley and to a lesser extent in the Moree area and in certain parts of South Australia. In northern New South Wales circumstances were not favourable for the specific incrimination of the insects responsible for myxomatosis transmission; the high kills recorded in the Moree area were the result, not of typical explosive outbreaks, but of low-intensity activity prolonged over several months. In the drier parts of South Australia, some doubt also remains as to the identity of the insects responsible for transmission, the evidence pointing to mosquitoes, sand-flies (Simuliidae and Seratopogonidae) and stick-fast fleas (*Echidnophaga* spp.) playing the vector role in varying combinations. The findings in the Murray Valley have been much more clear cut. Further studies of the mosquito, *Anopheles annulipes,* have confirmed its importance as a myxomatosis vector. Precipitin tests carried out by Mr. D. J. Lee, of the School of Public Health and Tropical Medicine in Sydney, and the isolation of the virus by Professor F. Fenner, of the Australian National University, from mosquitoes collected in outbreak areas have incriminated *A. annulipes* almost to the exclusion of all other mosquito species occurring in the region.

Over an extensive belt of country, ranging from South Australia to the highlands of New South Wales and the Australian Capital Territory, spring myxomatosis activity was correlated with the prevalence of simuliids (chiefly *Austrosimulium furiosum*), which occurred locally in plague numbers. Field observations pointed to the fact that these insects may have been responsible for spreading the disease into previously unaffected areas, e.g. on to high ridges and into the dry country lying north and south of the Murray. Evidence was obtained of the dispersal of simuliids, in large numbers, for distances of over 35 miles from their breeding places. Observations in this region also disclosed the interesting fact that the population of *Anopheles annulipes* persisted, harbouring in rabbit burrows, for two months after all surface breeding water had dried up. Myxomatosis vector investigations of the Wildlife Survey Section have revealed a degree of mobility in blood-sucking insects of a much greater order than previous work, both in Australia and overseas, had suggested.

The appearance and progress of some sort of adjustment between the rabbit and the myxoma virus, leading to a reduced case-mortality rate, is obviously of major significance in relation to the continued successful exploitation of the disease as an agent of rabbit control. Arrangements are therefore being made for the intensive investigation of this phenomenon in co-operation with Professor F. Fenner and his colleagues of the Australian National University. The work will involve serological surveys, the testing of virus strains "captured" in the field, and detailed rabbit population studies in selected areas to obtain more precise data on mortalities and the age structure of the population than the field observations to date have been able to furnish. This work may be said to have been initiated by the special investigations, mentioned above, in the three or four areas where a markedly reduced case-mortality rate had become evident last season. Here the results of field observations and serological tests carried out in Professor Fenner's laboratory indicated an infection rate of nearly 100 per cent. followed by an overall mortality of the order of only 50 per cent. The conditions associated with some of these anomalous outbreaks suggested that the most probable explanation of the reduced mortality was the local appearance of a strain of the virus with a lowered virulence. That the appearance and spread of such variant strains may be an important factor in the rabbit-virus adjustment that is taking place in the field is suggested by the recent isolation, from an area of disease activity near Canberra, of a strain of the virus that has been shown by passage in wild and laboratory rabbits to be definitely attenuated. Rabbits infected by this strain have recovered after an illness lasting 40-50 days (in the normal course of the disease death occurs on the eleventh to the fourteenth day). One sick animal was shown to be infectious for 56 days after having contracted the disease.

(*b*) *Biological Studies.*—During the course of th examination of the large samples that have been co lected periodically from a number of areas in con nexion with myxomatosis, the following informatio on rabbit reproduction in the eastern Riverina ha been obtained. Breeding in this region during the pas two years has been almost entirely limited to th wetter months (April-November). Young female born in April-May begin breeding towards the end c the year (October-November), young males do nc breed until the following season. The litter size varie from about four at the beginning of the season to seve at the end. This is apparently a function of age, sinc young rabbits examined always had small litters an at the commencement of each breeding season the breec ing population is predominantly young. The dat collected point to the fact that there is an almost com plete turnover in the rabbit population in one year. Ver few individuals seem to live longer than two year Reproduction and population studies are being intens fied, as it is now recognized that reliable informatio on such points as kitten mortality and mean length c life under conditions of high and low populatio density is needed for the clarification of certain prol lems of myxomatosis epidemiology.

The survey of endo- and ectoparasites of the rabb was continued as opportunity offered. A preliminar field study of refection (namely, the consumption b rabbits of a special form of faeces passed during perioc of inactivity, a process which is the physiologica equivalent of rumination in sheep or cattle) has bee carried out.

(*c*) *Miscellaneous Rabbit Control Investigations.*– In the early years of the Section some preliminar studies of poisons were carried out which showed tha sodium fluoroacetate (which was developed in Americ primarily as a rat poison, and is popularly known a "1080") held distinct promise as an agent for th destruction of rabbits. During the past summer th Tasmanian Department of Agriculture organized large-scale trial campaign using this poison, and a officer of the Wildlife Section was appointed t co-operate with the State authorities in the work. I is as yet too early to pass a verdict on the results c this campaign, but they have on the whole been ver encouraging and much useful information on poisonin practice has been gained. Attention has been given t the development of techniques for the study of certai fundamental aspects of rabbit poisoning, such as "fre feeding", furrow placement, and rabbit behaviour i relation to baits of different kinds.

Field trials of the power fumigator, developed b the Section to blow an atomized mixture of chloropicri and oil into rabbit warrens, were carried out on grazing property in the Mudgee, New South Wale district. Successful results confirmed the conclusio based on earlier tests that the machine had definit promise where it would not be practicable to use othe perhaps cheaper and quicker methods of control.

An experiment was initiated with the object c gaining a balanced understanding of the problems c practical rabbit control under present-day condition With the co-operation of Mr. B. Parkinson, of "Be Buckley", Mudgee, New South Wales, a field officer c the Section has been actively associated with the can paign of rabbit eradication that is being carried ou on the property. The rabbit situation (which has bee mitigated considerably by the effects of myxomatosis was assessed paddock by paddock, the most suitabl control measures decided on, and their efficacy an cost assessed. The results obtained to date indicat that the first and main attack on the rabbits infestin a grazing property can be carried out on a contrac basis. With this system the work can be done rapidl nd without interference to normal routine. It has ecome obvious, however, that the final "mopping-up" hase can be of long duration, but it is vital to the uccess of the whole scheme.

3. KANGAROO INVESTIGATIONS.

(Wildlife Survey Section.)

Field tests were continued on the use of sodium uoroacetate ("1080") as a component of salt licks curtail the excessive population of euros (*Macropus obustus*) in the pastoral country of the Roebourne ablelands, Western Australia. Results are yet inconusive as to the economic efficacy of the method, and ie stage has now been reached where precise experients on captive animals and more direct observations f feeding animals are necessary, together with general cological data. The investigations will be carried ut in co-operation with the State Department of griculture.

4. MUTTON BIRD INVESTIGATIONS.

(Wildlife Survey Section.)

The joint investigations with the Tasmanian Fauna oard on the economic biology of the mutton bird *Puffinus tenuirostris*) were continued in the Furneaux roup and extended to Trefoil Island, at the western id of Bass Strait.

In addition to the annual documenting of the breedig population at Fisher Island, the research islet near ady Barron, Flinders Island, an intensive observaon was made of the first part of the life cycle of the reeding birds. The adult birds on Fisher Island were udied from the time of the arrival of the first birds in the third week of September) until the hatching f the eggs (in mid-January). Gonad samples for orresponding histological studies were collected from eighbouring islands.

During the 1952-53 season 340 adult birds were hecked in on Fisher Island, compared with 325 birds the 1951-52 season and 290 in the 1950-51 season. notable observation was of a bird, No. 10706, which as ringed as a fledgling in March, 1950, on Fisher sland and recaptured on the same island on 16th anuary, 1953. There was no evidence, however, that was a local breeder.

5. DUCKS AND RICE CULTIVATION.

(Wildlife Survey Section.)

The problem of the depredations of wild ducks in ie irrigated rice crops was brought to the fore in 951-52, when drought conditions in the inland led to concentration of water-birds in the irrigation areas nd many complaints from rice-farmers of damage one to their crops. The main work has been done the Murrumbidgee Irrigation Area, but the Wakool rea was visited at four strategic times in the growth f the crop.

During the 1952-53 season the number of river ucks was about normal in the area, but the number f maned geese (wood duck) was below normal. All pecies studied (black duck, teal, shoveller, hardhead, naned goose, and tree duck) eat rice freely as planted rain and in the head. The maned goose also grazes n the young plant. In contrast to the 1951-52 season, hen abnormal numbers of maned geese were present the irrigation areas, the effects of duck visitations the rice crops were negligible.

Examinations of gizzards revealed that the principal oods of ducks in the rice fields are in the following rder of preference: (i) *Echinochloa crus-galli* (barnard grass, the most important weed of the rice fields); ii) rice; (iii) *Rumex* sp. (dock, another weed of the ice fields); and (iv) *Polygorum* sp. (smartweed).

6. IBIS INVESTIGATIONS.

(Wildlife Survey Section.)

There is a possibility that future developments of water conservation, which involve the construction of dams in the headwaters of the Murray-Darling system, may jeopardize the breeding-grounds of several species of water-birds. Among these, the straw-necked ibis (*Threskiornis spinicollis*) and the white ibis (*T. molucca*) are considered to be important predators of locusts and of insects generally. An investigation to determine the role of these birds in the natural control of locusts and to define measures for the preservation of their breeding haunts is under consideration.

Some preliminary observations of breeding distribution and behaviour were made in the Macquarie marshes, on the Murray, and in marshes on the Lachlan River. Preparations to study breeding requirements next season have been made on the Murray, and a survey of breeding distribution and numbers is planned. Observation of feeding habits and examination of stomach contents indicate a close dependence on freshwater invertebrates during the breeding season; Orthoptera, &c., of drier habitats appear when post-breeding dispersal of the birds has begun. The food preferences of ibises throughout the year will be surveyed more fully.

7. BIRD RINGING.

(Wildlife Survey Section.)

The establishment of a National Bird Ringing Scheme has been under discussion by the Organization and the Royal Australasian Ornithologists' Union for several years. It was decided that the provision of this service could properly be undertaken by the Wildlife Section. Australia is almost unique among the civilized countries of the world in not having an officially sponsored or assisted bird ringing scheme. Ringing for individual recognition is an essential feature of almost every scientific bird study. It is already employed by the Australian National Antarctic Research Expedition (which uses rings borrowed from the New Zealand authorities), and by one or two of the Australian States (who have indicated their willingness to participate in a national scheme), and it will be used in all the Section's ornithological investigations.

Plans were completed during the year for the establishment of an Australia-wide bird ringing scheme based on centres at Canberra and Perth. A complete series of numbered metal rings has been ordered, and rings will be supplied to approved persons or societies wishing to carry out studies of birds in Australia. It is hoped that a limited number of rings will be available during the coming breeding season, but the whole range of rings will not be received until the end of 1953.

In the Furneaux Group of islands, in the Bass Strait, a preliminary study of Cape Barren geese was begun (using rings obtained from New Zealand) to obtain data for estimating hunting pressure during the open season. Young birds were ringed on Goose, Rabbit, and Great Dog Islands. The Section is also co-operating in a ringing scheme on fairy penguins, initiated by the National Museum of Victoria, and employing the new flipper tag. Altogether the Section's officers marked 162 penguins in Bass Strait.

XI. UNDERDEVELOPED REGIONS.

1. GENERAL.

Large portions of Australia and its Territories are underdeveloped or are only very sparsely occupied. Low rainfall, poor soils, sparse pastures, inadequate water, and great distances from centres of dense population are some of the factors which have inhibited development. It is essential to understand the problems of these areas and where possible to solve them, so that either new developments can take place or the present level of production can be protected from the adverse effect of unwise exploitation.

The development of northern Australia has been slow in comparison with that of the southern and eastern States. Over 100 years have elapsed since the first settlements in the north, yet vast areas remain unproductive and are still only sparsely populated. In 1946, the Governments of the Commonwealth, Queensland, and Western Australia founded the Northern Australia Development Committee with the object of formulating a policy of development for northern Australia. The former Council for Scientific and Industrial Research was requested to indicate a series of land surveys of underdeveloped regions in order that this development potential might be more accurately assessed. In consequence, the Northern Australia Regional Survey, established later as the Organization's Land Research and Regional Survey Section, was organized to conduct these regional surveys.

Whilst the work of the Land Research and Regional Survey Section is thus concerned with the sparsely populated arid and semi-arid regions of the continent, much complementary work is carried out by other Divisions of the Organization on the development of low-producing areas in the less isolated regions. The Division of Biochemistry and General Nutrition is investigating problems of plant and animal nutrition on the Coonalpyn Downs, in South Australia (*see* Chapter III., Section 19), the Plant and Soils Laboratory is studying the wallum country in eastern Queensland (*see* Chapter III., Section 18), and the Division of Soils is making soil surveys throughout the Commonwealth (*see* Chapter II.). Allied work is also carried out by the Division of Plant Industry on plant and pasture ecology studies at Trangie, New South Wales, south-western Queensland, and elsewhere (*see* Chapter III.).

Land Research and Regional Survey Section.—This Section has its head-quarters at Canberra and field stations at Katherine, Northern Territory, and Ivanhoe (Kimberley, Western Australia). It has now mapped and surveyed over 200,000 square miles of territory, including the Katherine-Darwin region, the Barkly region, and the Townsville-Bowen region. The surveys take the form of broad-scale ecological studies which determine not only the distribution of the native vegetation but also the possibilities of growth and establishment of introduced crop and pasture species. They include the primary assessment of land-use potential, research into problems of agricultural and pastoral development of the arid and semi-arid zones and climatological studies, and also a general topographical survey showing the position of rivers, creeks, swamps, hills, valleys, and other natural features.

The immediate programme of the Section now includes the survey of the Gulf region in Queensland, the West Kimberleys, Alice Springs and Roper River regions of the Northern Territory, and the South-west Channel country and Cape York in Queensland. A unit has been established to commence a long-term survey of the Territories of Papua and New Guinea.

2. REGIONAL SURVEYS.

(Land Research and Regional Survey Section.)

Two regional survey units are now operating, one on the mainland of Australia and one in the Territories of Papua and New Guinea. The first unit has been in operation in northern Australia since 1946 and has already completed surveys of the Katherine-Darwin region (27,000 square miles), the Barkly region (120,000 square miles), the Townsville-Bowen region (6,000 square miles) and the Ord-Victoria River region (70,000 square miles). The New Guinea uni has been established within the last year and is abou to commence a survey of the Buna region of Papua

The major function of each group is to classify an map the lands of regions according to surface charac teristics of importance to the determinations of land-us potential. In order to do this studies must be made o the geology, geomorphology, soils, systematic botany and plant ecology of each region. Thus each unit con sists of a group of specialist scientific officers coverin these respective fields but working together in very close collaboration in the field. Some of these officer are seconded to the Land Research Section from othe organizations or other establishments of C.S.I.R.O To permit large regions to be surveyed and mapped i relatively short periods of time, special techniques hav been developed based on the interpretation of aeria photographs. These techniques involve a study of th origin of different types of country as well as a descrip tion of surface characteristics, and thus the final classi fication of lands has a fundamental basis to which sub sequent information on interpretations may be directl applied. The mapping unit is the land system, which is based on the pattern of topography, soils, and vege tation, the surface features of most direct significanc to land use.

The second function of each unit is to make the bes possible assessment of the possibilities of land us from the information on land characteristics, and from climatic records and records of present or past land use and by comparison with comparable environments out side the region. This assessment, together with th estimates of areas of each type of country mapped provides a basis of facts necessary for the formulation of policies concerning land development or conservation

(*a*) *Australian Mainland Survey.*—(i) *Ord-Victoria Rivers Region.*—The region is approximately 70,000 square miles in extent. It includes a large proportion of hilly country of very low pastoral value, par ticularly in the central portion of the region. Thirty eight land systems have been described and these hav been grouped into thirteen land-use groups. An examination of soils and climate indicates that dryland agriculture may be possible in some of the northern higher-rainfall areas, where conditions are comparabl to those at Katherine, Northern Territory. Th survey has mapped areas of "black soil" plains, lik those of the lower Ord River, along the lower Baine and Victoria Rivers. These would have similar possi bilities for the establishment of an irrigated agriculture if suitable sites for water conservation structures can be found. Smaller but useful areas of lighter-textured levee soils occur along the Wickham River near Vic toria River Downs, along the east side of the Baines River to the north of Kildurk, and on the Mantinea flats of the lower Ord River. If adequate water sup plies can be obtained such areas may be suitable for the production of high-return crops such as tobacco fruit, and vegetables. The northern parts of the region have not been greatly developed for pastoral purposes The major handicaps are tall, coarse pastures of low nutritive value, and poor stock management. The central and southern pastoral areas have better pastures and more-developed stock management. The provision of watering points and transport for fat and store stock are major problems retarding more intensive land use. The following maps are being prepared :— Geology, geomorphology, land system, land-use groups soils, vegetation, pastures, and field traverses.

(ii) *Fitzroy River Region.*—On the Lennard River the possibilties of water storage are limited by the small catchment and unsuitable rock formations at the dam site. The small areas of levee soils which appear suitable for high-return crops could utilize almost all of e water that could be regularly stored. The argaret River flats have relatively extensive areas good irrigable soils and it should be possible to conrve a considerable volume of water for irrigation. ore hydrological data are required to ascertain the racticability of the establishment of an irrigation roject, and agronomic investigations are necessary define the forms of production which would be most itable. The area warrants more detailed investigation.

The natural flooding of the Fitzroy River flats ppears to be too unreliable to be utilized as natural rigation on a broad scale without extensive water ntrol. Major hydrological studies are necessary efore the scope of water use in this portion of the gion can be defined.

The pindan soils near Derby are mostly deep sands d are not likely to support an extensive agriculture pendent upon rainfall alone. The small patches of avier soils are most suitable for irrigation from derground water supplies but the possibilities of velopment in this way are small.

(iii) *Gulf Region, Queensland.*—The first season of ld work in this region has been commenced. It vers an area of about 110,000 square miles and inudes the drainage basins of the Leichhardt, Flinders, d Einasleigh Rivers. The mean annual rainfall nges from 15 inches in the south-western corner to inches in the north-eastern corner. The region has en reasonably well developed for cattle grazing except the central and northern hilly or sandy "desert" untry.

(*b*) *Papua-New Guinea Survey.*—The New Guinea it has now been organized and will begin work in e Buna region. The area covers approximately 500 square miles, extending from Mount Lamington d Kokoda north to the mouth of the Mambare River. he region includes the area devastated by the 1952 uption of Mount Lamington, the lower gently sloping mice plains, extensive swamp and delta formations ar the coast, the Yodda Valley, the rugged hilly untry of the Ajura Kijala Range, and parts of the wen Stanley and Hydrographer Ranges. This area partly served by roads and is partly accessible by at. Parts are accessible by foot patrols along tracks d others can only be sampled by traverses through rgin country. Vertical aerial photographs cover rtion of the region and the remainder has an incomete cover by trimetrogon photographs.

This first survey in Papua will be largely experiental, and a period of training of new personnel. he principles developed in the northern Australia rveys will be applied but methods will have to be lapted to Papua conditions. The unit will have perience with a variety of working conditions in is region and it should be able to determine the techques most applicable for future work in Papua and ew Guinea. Officers of various New Guinea departents are co-operating with the unit both in the ganization and supply of equipment and in the ld work.

3. AGRICULTURAL RESEARCH IN NORTH AUSTRALIA.

(Land Research and Regional Survey Section.)

(*a*) *Katherine Research Station.*—In addition to search by the Land Research and Regional Survey ection into problems of dryland agriculture, the work this station includes a programme of testing plant troductions and investigations into the possibilities tobacco-growing conducted by the Division of Plant dustry (*see* Chapter III., Section 8).

(i) *Crops.*—In previous years it has been shown that average seasons satisfactory yields of peanuts, tton, and grain sorghum should be achieved, but ere is considerable seasonal variation. In the season just ended all crops made a promising start but suffered severely from a mid-season dry period which forced early maturity. Wet weather which followed in early April brought about a renewal of growth but was too late to affect yields advantageously. This late wet spell caused considerable damage to crops that were mature. Under the adverse conditions of last season peanuts appeared to have been affected least, sorghum to a major extent, and cotton very severely. Both peanuts and sorghum gave yields up to 1,000 lb./acre but the cotton crop was reduced to negligible quantities of poor lint by the dry spell and the subsequent wet period while bolls were opening. A preliminary examination of climatic data suggests that the last two seasons were worse than would normally be expected. A more detailed examination of the data is being made to assess more accurately the expectation of different kinds of seasons and the likely proportion of crop failures.

In general, varieties of all three crops, selected as superior in previous seasons, maintained their relative superiority under these adverse conditions. Investigations on drought responses of sorghum varieties have indicated that plant height *per se* is of no importance. When a variety Hegari and its dwarf mutant were grown side by side, the dwarf variety suffered far more from drought than the normal.

Of the other crops under investigation, sunflower, a crop which has a reputation for drought resistance, and the fibre plant kenaf have again failed at Katherine this season. Grain pulses (*Phaseolus* spp.), including an edible variety, produced up to 600 lb./acre.

(ii) *Fertilizer and Spacing Experiments.*—Experiments in the 1950-51 wet season indicated that the fertilizer dressing so far tried and the crop spacings adopted were probably suboptimal for good seasons. Experiments on these points, designed to achieve maximum production, laid down in the last two subnormal seasons have failed in their objective because water has been limited. Present experiments are planned to determine the fertilizer and spacing practices which are a suitable compromise between the optimum for good seasons and those which are most effective in dry seasons.

(iii) *Soil Moisture Studies.*—Recent droughts have emphasized the necessity for obtaining maximum utilization of rainfall in subnormal seasons. Attempts have been made to avoid run-off and to get as much of the rain into the soil as possible, through cultivation and tillage methods. Direct water conservation through basin listing has also been attempted. It has been shown that the red earth soils of this region have a very limited range of available water and that the amount of water which can be held in that part of the profile explored by roots is insufficient to carry well-grown plants through a rainless period such as the one that occurred during the recent growing season. The available moisture status of these soils is lower than would be inferred from the mechanical analysis. Rainfall penetration and subsequent utilization have been studied by electrometric measurements using gypsum blocks. The collection of water by basin listing did not have any beneficial effects on the growth of a cotton crop, nor did it delay the onset of drought symptoms.

(iv) *Cultivation and Tillage Practices.*—Significant differences have been obtained in the response to cultivation and tillage practices and, in general, the response is related to the differential penetration of early rain. While these red soils are normally free draining internally, they are poorly structured, are very easily reduced to a powder form, and are unstable when wetted. Any form of cultivation which produces a bulk of fine material leads to reduced water penetration. The most suitable form of land preparation seems to be to break up the soil to a depth of about 8 inches, leaving it in the form of large clods, with as little fine material as possible. Subsequent tillage is necessary to produce seed beds and to keep the surface open and receptive to rain, but it should be as dust free as possible. Seed-bed preparation in general poses several problems, the chief one being to get the seed placed on a firm, moist seed bed and adequately covered with soil that will not set so hard that seeds have difficulty in emerging. With cotton, emergence difficulties have been overcome by hill planting, that is, planting four to six seeds together at intervals of about 1 foot.

(v) *Disease.*—A feature of the past season has been the unusual incidence of disease. Sorghum crops were ruined, at a very late stage in their growth when good crops seemed assured, by "charcoal rot" caused by a *Sclerotium* sp. It is well known that plants under acute stress are especially liable to this disease, and this fits the observation (by electrometric measurements) that the moisture content of the soils carrying sorghum had been reduced to wilting point at the time the disease was first noticed. Sunflowers were attacked by the same organism, and at the same period. Bulk crops of *Phaseolus* spp., which showed premature senescence as a result of the drought, were badly infected by *Phoma* sp.

Considerable progress has been made in understanding the peanut disease of the Katherine district. The usual causal organism appears to be the same *Sclerotium* sp. that attacks sorghum and sunflower. Observations have shown that the disease may gain access to ripening seed while it is still in the ground and may cause little or no visible external damage to the seed. When such seeds are planted, the organism becomes active and may destroy the seed during germination, or it may take some little time to become lethal and give rise to seedling collapse. In this phase, the disease appears identical with the "concealed damage" or "hidden disease" reported in recent years from the United States of America. The pathogen responsible for seed rot or for seedling collapse appears widely distributed in the soil and can attack plants at later stages when the disease is referred to as "crown rot" or "wilt". Primary invasions by the *Sclerotium* are in most cases followed, and masked, by heavy infections from secondary fungi such as *Aspergillus* spp. Nuts sown in land inoculated with trash from previous diseased crops have shown 70-90 per cent. failure. Considerable protection from soil-borne attack can be obtained by dusting seeds with a fungicidal dust before planting, but such protection is by no means complete. Careful seed selection and storage, protection with fungicidal dust, and increased rates of sowing to ensure good stands, in spite of some emergence failures, have permitted good crops to be obtained from diseased land sown continuously to peanuts for four years. Further studies on the apparent resistance to disease shown in previous years by certain introduced varieties indicate that they may not be truly resistant and that their previous freedom from disease may have been due, at least in part, to their relative freedom from internal infection. Investigations on this disease and its related symptoms on other crops are being continued.

(vi) *Pests.*—The adverse season was characterized also by unusual pest problems, most probably connected with the mid-season drought. In normal years, birds can be effectively discouraged by dawn and dusk gun patrols, while control of cover on the margins adjacent to cultivation discourages marsupials. This year, however, such measures were ineffective and the few surviving crops were heavily damaged by birds and marsupials. In previous years, there has been a jassid problem in cotton only with ratoon crops and ratooning was abandoned for this reason. This year, howeve jassids have become a serious problem on all crops an unless the jassids are a reflection of the broken seaso some control measures must be sought.

The widespread occurrence of nematodes has bee reported, but no evidence is as yet available as to i effects on crops.

(vii) *Native Pastures.*—Regional surveys carrie out by the Section have indicated that only a sma proportion of the total area is suitable for intensiv agriculture and that, for much of the area, pastora industries would appear to offer most scope. Work ha commenced on an ecological study of the nativ pastures and on possible practical methods of improving their value. The cumulative effect of the reduce rainfall over the last two seasons has been to damag severely many of the native grass species, especiall the perennial *Themeda australis* and *Sehima nervosu* and the tall annuals such as *Sorghum* spp. Stoo which escaped destruction have been so badly damage that in many cases only a few weak shoots have grow The partial suppression of the normally domina perennials has resulted in a great increase in annua species.

Studies of factors controlling the distribution o species have indicated that water and nutrition pla a very prominent part, and that microrelief is of grea importance. Very slight variations in topograph cause small sinks where water and eroded humus-ric surface material collect. The more fertile areas i general carry perennial grasses, while the less fertil areas carry annual species.

Studies have also been made on the effects of grazin on native pastures. An area which originally consiste almost entirely of perennial grasses is now, after tw years of grazing, composed of 98.5 per cent. annual and only 1.5 per cent of perennial species. A contro ungrazed area, now contains 60 per cent. perennial and 40 per cent. annuals, the intrusion of the annual being a result of drought damage. Yield of dry matte has been relatively unaffected so far by the chang from perennial to annual species as a result of heav grazing. Attempts to introduce Townsville lucern (*Stylosanthes sundaica*) into native pastures has give erratic results. Grazing facilitates introduction up to point. It favours Townsville lucerne because it reduce competition from the grass (probably from shading since the grass is preferentially grazed throughout th wet season. On the other hand, Townsville lucern seed seems particularly susceptible to removal by flowing water, and can be removed completely from area where overgrazing has left the soil bare and subjec to run-off.

(viii) *Introduced Pastures.*—The only grasses whic have withstood the unfavorable conditions of the las two seasons are species of *Centhrus.* Although buffe (*C. ciliaris*) and Birdwood (*C. setigerus*) are outstanding in their persistence under conditions of lo rainfall and low fertility and although they respon very well to higher levels of fertility (phosphate) i seems probable that, under more normal rainfall conditions, other species, such as Rhodes grass which ha been less persistent in drought, may be much mor productive at all levels of fertility. Experiments ar in progress with a range of the more promising pastur species in which it is planned to determine the effect of density of stand and fertility level on yield an persistence over a number of years. Other experiment are designed to determine the persistence of variou legumes and to measure the possible interactio between grasses and legumes.

(*b*) *Kimberley Research Station.*—(i) *Crops.*— Experimental plantings of sugar-cane and rice hav both continued to give promising results. As crops o type would be very suitable for land settlement er irrigation, investigations of both are being con- rably expanded.

ugar-cane: The first sugar-cane variety trial ted in October, 1951, and harvested ten months r gave a mean yield of 25 tons of cane per acre. mall trial planted at the same time with the same eties but harvested at eighteen and a half months given higher yields, with one variety producing up 0 tons of cane per acre. The longer growing period this trial emphasized varietal differences. Addi- al equipment is now available to permit planting cultivating under better conditions. A third ety trial planted in August, 1952, is showing the efit of this improvement and estimates of yield of growing crop are high. Preliminary growth studies e emphasized the marked seasonal growth of cane his locality and a time of planting experiment has n begun to determine how plantings can best be usted to this factor. Particular attention is now g paid to sugar content. Preliminary evidence n hand refractometer measurements indicate that s satisfactory but trials are now in progress in ch the sucrose content of the cane is being measured oughout the ripening season.

ice: A large collection of tropical rice varieties is available. These have been grown for preliminary ervations and multiplication in large wire-netting es which prevent bird damage. From these small sery rows a number of promising varieties, esti- ed to have given grain yields approaching 2 s/acre, have been selected for further study. hanical seeding techniques are now being investi- ed in preparation for larger plantings. The high peratures prevalent at the time when seed of mer crops must be sown constitute an establishment blem.

afflower: Irrigated crops of safflower, grown in the season, have given yields varying from 1,300 to 0 lb./acre according to variety. Oil contents have n determined and range from 27 to 35 per cent. s crop, which produces promising industrial oil, is g considered for rotation with rice crops. Experi- ts in progress are designed to determine relations veen spacing, watering, and yield.

ther Crops: Summer irrigated crops of peanuts, ghum and kenaf have been grown but yields in this son of low atmospheric humidity were lower than former years. A 6-acre block of grain sorghum wn under irrigation during the winter period pro- ed at the rate of 1,600 lb. grain per acre.

ii) *Fertilizer Experiments.*—It has been found that ar-cane shows marked responses to phosphate and itrogen, but not to potash. An experiment is now progress exploring the economic limits of fertilizer ease. To date, the best yields have resulted from highest fertilizer application of 4 cwt. each of erphosphate and ammonium sulphate. There are ications that ratoon crops will require a higher ogen supply than the plant crop.

xploratory pot trials with rice have indicated ked responses in growth and in tillering with nonium sulphate which is much more effective when ed at a depth below 2 inches in the soil than when lied on the surface. Sodium nitrate has failed to any significant response, whether applied to the face or at a depth. All previous field trials have wn the necessity of superphosphate for adequate wth.

iii) *Irrigation.*—Erratic results obtained in past ghum and safflower experiments are believed to have n due to incomplete control of irrigation resulting n difficulties of accurate water reticulation. A eful study of irrigation requirements is in progress. Use is being made of gypsum blocks to indicate moisture status in the soil, and siphons of 2-in. diameter non-flexible plastic piping shaped to fit the channel banks are being used for distributing water from the head ditch to the irrigation furrows. They have proved to be much more satisfactory than pipe inlets, or V cuts through the channel banks.

With sugar-cane, observations on plant behaviour, as well as resistance readings, have indicated that water is required when the block resistance exceeds 10,000 ohms at a depth of not less than 12 inches; this corresponds to a watering interval of ten-seventeen days under dry season conditions.

(iv) *Disease.*—The only diseases of note during the past year have been on peanuts. A 6-acre block of peanuts in a rotation trial during the 1951-52 wet season had been devastated by an outbreak of crown rot during the late stages of growth. Peanuts are being grown again on this land in the 1952-53 wet season, and again disease is very prevalent. It was first apparent in the same patches as last year's attack. There is some evidence that plants are more susceptible to the disease, or at least show the effects more clearly, when soil moisture is deficient. It is of interest to note that experience here with new varieties is parallel with that of Katherine in that varieties which show a high degree of freedom from the disease when first introduced fail to maintain it in subsequent plantings. It seems that newly introduced seed probably has little "hidden infection" and that as seed stocks are multiplied, an increasing proportion of the seed becomes infected, thus giving the illusion that the strain is losing field resistance. These indications are of great importance in emphasizing the necessity for clean seed stocks for successful peanut production. *Cercospora* leaf spot showed a moderate incidence on peanuts. It was also present on *Vigna* spp. growing on the levee.

(v) *Pests.*—The station has had unusual freedom from major pests during the past season. Grasshoppers did not attain plague proportions but the combined population of several species was sufficient in April-May to cause some damage to young sugar-cane. Further damage was prevented with a mixture of BHC and DDT dusts.

The usual bird pests have not been present so far this year. Even rice planted without the protection of a wire cage has suffered only slight damage by finches. It is believed that the late heavy rains ensured a plentiful natural food supply for the birds at the time when our own crops were ripening. A stem borer of rice, tentatively identified as a *Schoenobius* sp., was fairly common among the later-maturing rice varieties. During May, some pupating and emerging parasitic wasps have been found in affected stems.

An outbreak of a sugar-cane stem borer caused concern in July-October, 1952. This stem borer is not a usual one and has not as yet been definitely identified. Differences in degree of attack on the several varieties was observed. Certain varieties of cane were unaffected, while others were heavily attacked. The attacks subsided late in the year without any great permanent damage being done and have not, so far, reappeared.

(vi) *Irrigated Pastures.*—During the year observation plots of a wide range of possible pasture grasses and legumes were established on the red levee soils. Although pastures cannot be regarded as a suitable basis for establishing an irrigation settlement in the region, they may be suitable as a factor in the maintenance of soil fertility. The very marked contrast between growth on the levee and on heavy clay soils has strongly emphasized the special problems in establishing and maintaining pastures on the heavy clay, which is the dominant soil type.

It has been previously reported that pastures of Rhodes grass made good initial growth but began to decline even before they were fully established. This problem is being examined and the effects of fertilizer and ripping on an old Rhodes grass pasture were studied. Ammonium sulphate gave a marked but ephemeral response but ripping did not cause any immediate response although slight benefits appeared later.

In a grazing experiment in which five grasses have been established with and without legumes (*Clitoria* and *Stylosanthes*), three of the grasses, *Brachiaria mutica* (Para), *Panicum maximum* (Guinea), and *Andropogon gayanus*, have shown improved colour and vigour when associated with *Clitoria ternatea*, and to a lesser extent with *Stylosanthes gracilis* (stylo). The grasses showing no response are *Cenchrus ciliaris* and *Paspalum scrobiculatum* (scrobic). It is possible that the lack of response by these grasses is connected with selective and excessive grazing of the legumes in these pastures. These five grasses have persisted well, and with *Andropogon* there has been a steady improvement in stand and productivity leading to an increased stocking rate. The Guinea, scrobic, and *Andropogon* pastures appear capable of maintaining a liveweight increase approaching 2 lb. per acre per day. *Cenchrus ciliaris* has given much better results when grazed continuously as compared with intermittent grazing, for the former practice has greatly reduced the development of stemmy, unpalatable material. However, even with the modified system, and with the best pasture so far as cover is concerned, this grass has given much lower liveweight gains than the other grasses, and the legume components are seriously overgrazed.

An area of *Clitoria* has been established as one step in the study of methods of establishment of a grass-legume pasture. There is an appreciable proportion of volunteer species, including grasses, and steers have shown rapid improvement, without any ill effects, on this *Clitoria*-dominant mixture.

The decadent effects noted on Rhodes grass pastures have also been apparent on grasses maintained as fodder crops, including *Pennisetum purpureum* (elephant), *Panicum maximum* (Guinea), and *Sorghum sudanense* (Sudan grass). Thus elephant grass rapidly established vigorous stools when first planted, and achieved high production, but production in the second year has been only one-third of that in the first season, yielding little over a ton of dry matter per acre.

4. CLIMATOLOGY.

(Land Research and Regional Survey Section.)

A small unit within the Section has now been established for some time studying the influence of climate on plant growth. Its overall function is to assist in the assessment of the land-use potentialities of the areas surveyed by the Section's regional survey unit. The unit has continued to provide general information to other units of the Section. A report of the climate of the Ord-Victoria Rivers Region has been completed as part of the general report on that region, and other reports are in preparation for the current surveys in both northern Australia and New Guinea. A detailed examination of the climate at Katherine, Northern Territory, has also been made. This includes a study of the distribution, amount, variability, and intensity of the rainfall, and of the annual distribution of temperature, humidity, and photoperiod. In addition, the length of the growing season has been estimated for the 67 years of records available, as well as the expected duration and frequency of dry periods within the wet season. The information contained in this study will be applied to the research programmes being conducted in the dry monsoonal zone. At the Katherine Research Station studies on environmental factors in relation crop growth and production have been continued, particular with crops of cotton, peanuts, and gra sorghum, and further studies of these factors wi respect to native pastures have been commenced. Apa from standard meteorological equipment, extra recor ing equipment was used for the measurement of climat factors; gypsum blocks and thermistors were used f soil moisture and soil temperature determinatio respectively. Regular observations were also made water deficit, growth, transpiration, and stomat activity within the crop plants under investigation, relation to the climatic and edaphic factors. At t Kimberley Research Station investigations on the wat requirements of irrigated sugar-cane have been co menced.

In the season which has just ended the wetting fro was traced as it moved downward in the soil wi each rainfall increment. Root development by t crop plants was observed to progressively exploit ea new wetted zone, and this development was most mark as the soil moisture content in the upper layers w decreased and became less readily available. Owi to the small proportion of available moisture in t profile (the field capacity of the soil is approximate 21 per cent. and the permanent wilting point 13 p cent.), stress conditions in plants began to appe within a few days of the commencement of each dryi cycle. Not until water deficits within the tissu became pronounced, however, was an effect on tra spiration rate and growth noted. Maximum depth water penetration on the areas under study reach approximately 5½ feet. The roots of all crops we distributed through the soil to this depth and th lowered the water content of the whole of the wett zone to the permanent wilting percentage before grow ceased. On other areas at the station, particular those topographically favoured, penetration to 7½ fe was observed.

5. ARID ZONE RESEARCH.

(Land Research and Regional Survey Section.)

The arid and semi-arid zones of Australia suppo large numbers of sheep and cattle even though the ra of stocking per unit area is low. It is of importance maintain these areas at as high a productive level possible and to raise this where practicable. The i vestigation of this field has been commenced and report has been prepared following a prelimina examination of the Alice Springs region. This repo draws attention to the necessity for ecological studies the native vegetation and its responses to grazi and climatic crises, in order that pasture manageme may be planned to prevent deterioration. It also in cates the importance of ecological studies of exot species. This is a necessary basis for their practic dissemination and establishment in native plant co munities which have a level of production too low justify the expenditure involved in the more usu practices of pasture improvement. In such areas sma scale intensive forms of production may be of conside able local significance and hence the possibilities irrigation from underground or small conservati sources should also be examined. After the recent go season in the Alice Springs area, an extensive collecti of botanical specimens was made as a foundation to t intended study of the various plant communities.

XII. FISHERIES.

1. GENERAL.

Fundamental information on Australia's mari resources will lead to their full and economic exploit tion. The Organization through its Division Fisheries aims to obtain this information. A bas study is made on migrations and other habits of fi

Australian waters, adaptation of methods of catching ferent varieties to locally prevailing conditions, and e location for fishing grounds.

Division of Fisheries.—The Division's research pro- amme can be subdivided under (*a*) oceanography iological and hydrological); (*b*) survey and appraisal the estuaries (particularly those of the important t coast rivers); and (*c*) cultural studies, including e possibilities of fish farming in the coastal lakes and goons and in the rivers and freshwater ponds, pearl d pearl shell culture in the tropical northern waters, d other studies on shellfish.

The Division also undertakes work on fish preser- tion in co-operation with the Division of Food eservation and Transport (*see* Chapter XIII., ction 6).

Oceanographical studies were again limited to coastal ters and this must continue until the projected new 0-ft. trawler-oceanographic vessel goes into com- ssion.

Culture and fish farming studies, begun in very recent ars, were carried a stage forward, particularly with gard to knowledge of the basic factors in operation.

The central laboratory at Cronulla, New South ales, and the branch laboratories at Dunwich and ursday Island, Queensland, Melbourne, Victoria, rth, Western Australia, and Hobart, Tasmania, re maintained in continuous operation.

In Queensland, the Division continues to operate om the research stations supplied by the Queens- nd Government. In New South Wales, the Division s agreed to carry out in co-operation with the State sheries Department a scientific survey of Lake acquarie and to investigate the apparent decline in ent years in the catch of fish taken in that area. ring the year an officer of the Division visited New aland to study the trout investigations and stream provement work, by arrangement with the Tasmanian lmon and Freshwater Fisheries Commission.

In 1952, members of the New Zealand Oceano- aphic Committee discussed problems with officers the Division. Through two of its officers the Divi- n is represented on the Standing Committee on eanography of the Pacific Science Congress. It has o been associated with the inauguration and develop- nt of the Indo-Pacific Fisheries Council of the Food d Agricultural Organization.

The crayfish exporters in Western Australia have ade donations towards the cost of equipment and ld surveys and it is also desired to make grateful knowledgment of the following for co-operation and sistance during the year: the Department of Agri- lture and the Police Department in Tasmania, the estern Australian Institute of Agriculture and the iversity Department of Zoology, the Australian haling Commission, the NorWest Trading Co., hale Products Ltd., the Royal Australian Navy, uddart Parker Ltd., and all State Departments of sheries.

2. Operations of Research Vessels.

(Division of Fisheries.)

(*a*) *F.R.V.* Derwent Hunter.—After a long refit R.V. *Derwent Hunter* returned to sea in August, 52, and made two long cruises during the year, cover- g the southern waters of New South Wales, Bass rait, and eastern Tasmanian and South Australian ters.

(*b*) *F.R.V.* Gahleru.—She made two cruises to roote Eylandt in the Gulf of Carpentaria to prospect r new shell beds. The *Gahleru* spent approximately elve weeks in this area and payable quantities of fair, average quality (F.A.Q. in the trade) shell were found in a number of places between Groote Eylandt and the mainland.

(*c*) *Other Vessels.*—Onshore hydrological traverses, preliminary prawn surveys at Shark Bay, Exmouth Gulf, and the Broome area, together with crayfish surveys in Geographe Bay and Cape Naturaliste, Western Australia, were carried out with patrol vessel *Lancelin* and small craft of the Department of Fisheries and Game.

During December, January, and part of February, 1953, the Division chartered the fishing vessel *Suda Bay* so that biological information on the marine crayfishes of the Cape Naturaliste to Hamelin Bay area could be obtained.

3. Whaling.

(Division of Fisheries.)

Observations on the west Australian stock of humpback whales continued at the whaling stations at Carnarvon and Point Cloates and, with the inauguration of whaling on the east coast, observations were made on the east Australian humpback stock. On the west coast, 1,187 humpback whales were killed and 540 of these were examined by research officers; of the 600 humpback whales taken on the east coast, 423 were similarly examined. A preliminary assessment of the mass of biometrical data accumulated during this and previous years does not so far suggest any striking differences between the two stocks, but the figures need a more detailed and critical examination.

It was shown that the proportion of female humpback whales in the Western Australian catch for 1952 exceeded that of previous seasons. Further, a concomitant increase in the proportion of immaturity found among whales may indicate that the catching intensity is bearing heavily upon the male portion of the population and is now shifting to the other sex. These two characteristics were not found in the east Australian catch, where the percentage of females killed was comparable to that in earlier years on the west coast, and the percentage of immaturity among males was lower than has been recorded from the west coast since the commencement of the present series of whaling operations. It was determined that female humpback whales reach sexual maturity at an average length of about 38 ft. 6 in. and males at about 36 ft. 6 in. Very few (about 1.2 per cent.) of the whales examined on the west coast were found to be physically mature, which confirms the finding of the previous season. It is possible that the east coast catch contained a higher percentage of physically mature whales, but the observations made were insufficient to prove this. The mean length of fully physically mature female humpbacks was determined to be 45 ft. 6 in. and of males 42 ft. 2 in.

On the east coast three very early embryos of lengths from 0.87 to 1.8 cm. were obtained. On the west coast a considerable proportion of the females taken were found to be in late pregnancy and, during the early part of the season, a very high proportion of the remainder were lactating.

Aerial observations conducted on the western whaling grounds showed that speed of movement of humpback whales varied from 2.6 to 7.7 kt., and that the general change from a northerly to a southerly migration occurred about 24th August. The percentage accompanied by new-born calves increased markedly from September to October, indicating that many births must have taken place during the latter half of the season and that a considerable proportion of the whales other than these had already left the grounds.

4. SEA FISHERIES.

(Division of Fisheries.)

In south-eastern waters more time is now being devoted to observations on the water and plankton conditions, and studies of gummy shark and the fishes of the continental slope are also being made. School shark and barracouta investigations are well advanced and are being reduced.

The long-line fishing operations on the slope of the continental shelf, i.e. on bottoms over 100 fathoms deep, continue to yield most interesting results. Fish have now been taken 600 fathoms—nearly three-quarters of a mile—below the surface.

Progress has also been made in the recording of underwater shoals of pelagic fish by echo-sounding. Explosives are dropped on detected shoals so that specimens will float up for identification. Echogram traces of jack mackerel and anchovy have now been identified in this way.

(*a*) *Barracouta* (Thyrsites atun).—The recorded catch of headed and cleaned barracouta in all States fell from 13.7 million lb. in 1948-49 to 9.0 million lb. in 1949-50, 6.5 million lb. in 1950-51, and 6.2 million lb. (the average pre-war level) in 1951-52. The fall in the first year was due to a lessening of demand and had been predicted. The subsequent further fall was due to natural fluctuation in the availability of fish.

There are summer-spawning populations in Bass Strait and eastern Tasmania, and winter-spawning populations in eastern Victoria, New South Wales, and South Australia. The barracouta of western Tasmania are virtually unfished and unknown.

This recognition of different populations does not depend on spawning seasons only. The average size of Bass Strait barracouta is consistently less than that of east Tasmanian barracouta, as shown by tens of thousands of measurements in different years. The monthly records of catch and catch per boat at different fishing ports show that barracouta migrate from east to west in Bass Strait and back again each year, simultaneously on the Victorian and Tasmanian coasts; in eastern Tasmania, and likewise in eastern Victoria and New South Wales, there are similar migrations on a similar scale, but running north and south.

The relationship of the adult fish, rather than broods of young, to the environment is now being investigated with particular reference to the principal food of the barracouta, the euphausian *Nyctiphanes australis*.

Only seven tagged barracouta have been recovered, out of 4,500 released. The barracouta catch could be increased ten-fold by adequately exploiting all the available populations without overfishing any of them; this would represent an increase of 50 per cent. in the total Australian catch of fish and shellfish.

The seasonal cycle of bodily condition has been further studied, especially in the Bass Strait population. From observations in five consecutive fishing seasons, it can be said that the first barracouta of the season, those of the early spring, are fat; then during the late spring, summer, and autumn barracouta first lose condition rapidly, regain most of it, lose some again, and then again improve—being sometimes as fat at the end of the fishing season as at the beginning. These results suggest that the Bass Strait fish, which disappear in winter, might then be in better condition than most of those taken during the fishing season. The wintering area of this population is being sought and is probably in eastern Bass Strait, in mid waters or on the bottom.

(*b*) *School Shark* (Galeorhinus australis), *and Gummy Shark* (Emissola antarctica).—A limited programme on the second shark species of commercial importance, gummy shark, was started. The resear vessel has continued an intensive tagging programm on both shark species as far as South Australian water

Tagging results show that there is only one stock school sharks in the waters of Victoria, Tasmani and New South Wales, and there are reasons for belie ing that a depletionary trend is evident. Out of 2 gummy sharks tagged, there were two early loc recoveries.

(*c*) *Fishes of the Continental Slope.*—To determi depth distribution of fishes, long-line fishing in wate over the slope of the continental shelf, 100-600 fathor deep, has been continued in east and west Bass Stra off Eden, New South Wales, and off Triabunna, Ta mania. The three main teleost species so far encou tered in this work—*Mora* sp., *Genypterus blacodes*, a *Hyperoglyphe porosa*—are in evidence at the majori of stations worked.

(*d*) *Tuna.*—Growth studies were continued southern bluefin tuna (*Thunnus maccoyi*) and we facilitated by an abnormally rich occurrence of sma fish in inshore waters of New South Wales for t duration of the season.

Temperature correlations were continued and resul indicate that changes in temperature associated wi current lines tend to aggregate the fish.

During one fishing test in *offshore* waters in t Eden area, a 40-ft. boat, modified for livebait fishin caught about 10 tons of tuna in one day. The 43 oth boats fishing *inshore* on the same day, using the tr method, averaged only half a ton each. It is becomi clear that the main body of the southern bluefin tu population frequents offshore waters. Captures we made up to 70 miles off Investigator Strait, Sou Australia. Albacore (*Thunnus germo*) and strip tuna (*Katsuwonus pelamis*) were recorded for t first time in South Australian waters. The purs seiner *Tacoma* made three catches of up to 4 to each of southern bluefin tuna in Boston Bay, Sou Australia, during March, 1953.

(*e*) *Australian Salmon* (Arripis trutta).—To te the hypothesis that fish present along the Victori coastline during the late summer-early autumn peri move into New South Wales waters during the la autumn-early winter period, 300 fish were released Lakes Entrance in April, 1952. During April a May nine recoveries were obtained in the Bass Stra area. Between June and November 32 recoveries we obtained from eastern Victorian-New South Wal areas, to as far north as Jervis Bay. Although it thus apparent that the movement between Victoria a New South Wales takes place, some fish remain the Bass Strait region.

Routine meristic counts and biometrical measu ments have been continued on the salmon of Sou and Western Australia. Most of the tagging expe ments have been carried out in South Australian wate to determine whether or not the salmon of these wate migrate to Western Australia. In June, 1952, 2,0 salmon were released at Ceduna, with some early loc recoveries. At Port Noarlunga, 220 fish were releas in December, 1952, with 49 nearby recoveri demonstrating a non-migratory phase.

In late November, 1952, 100 large fish were releas at American River, Kangaroo Island, with three loc recoveries. At Port Lincoln approximately 170 salm were released during April, 1953. There was no ear recovery. During October, 1952, 350 fish were releas in Tasmanian waters, with a few local recoveries. Cheyne Beach, Western Australia, 100 salmon we released in an attempt to confirm the westerly spawni run indicated by previous tagging experiments. O fish, recovered at Hamelin Bay, had travell approximately 220 miles in fourteen days.

(*f*) *Ruff* (Arripis georgianus).—Preliminary racial
idies were made. Ruffs with well-developed gonads
ve never been reliably recorded from South Aus-
lia. In Western Australia, however, samples con-
ned up to 100 per cent. of spawning individuals. It
now considered that spawning takes place only in
estern Australia, the reproductive cycle being gene-
ally controlled but inhibited by unsuitable environ-
ntal conditions. Further evidence is being sought.

Since the initiation of an intensive tagging pro-
amme in February, 1952, approximately 7,500 ruffs
ve been released in South and Western Australian
ters, to determine whether active interchange takes
ace along the entire coastline. There were many
al recoveries and a few from some distance (maxi-
ım, 350 miles covered in four months).

In South Australia tagging was undertaken mainly
test a hypothesis that fish of South Australia move
o Western Australian waters for spawning. Best-
avelled fish were recovered at Esperance, Western
ıstralia, a distance of 600 miles after a period of
ght months, at Bremer Bay, Western Australia, a
stance of 730 miles after ten months, and at Rottnest
land, Western Australia, a distance of 1,250 miles
five months.

During 1953, in Western Australia, 1,480 fish were
eased. In South Australia, during April, 1,850 ruffs
re liberated, without early recovery.

(*g*) *Australian Trawl Fisheries.*—The work on
is important fishery is almost at a standstill and will
main so until the Division has its own trawler.
ıring the year an analysis has been made of avail-
le statistics.

(i) *West Australian Trawl Fishery.*—The company,
nglo-Australian Fisheries Pty. Ltd., who were operat-
g in the region of the Great Australian Bight from
ptember, 1949, ceased operations on 23rd March,
52. Copies of the company's cruise reports and
awler logs have been used to summarize the results
this trawl-fishing enterprise and to compare the
sults with previous ventures of trawl fishing in the
reat Australian Bight, and past and present trawl-
hing operations in east Australian waters. The
sults show the general commercial possibilities for
awl fishing in the restricted region of the Great
ıstralian Bight.

(ii) *New South Wales Trawl Fishery.*—The avail-
le catch and effort statistics of the New South Wales
awl-fishing industry have been brought up to date
d are being maintained with especial reference
the three main species *Neoplatycephalus richardsoni,*
emadactylus macropterus, and *Trachichthodes*
inis. A summarized analysis has been the basis for
itiating discussions on proposals submitted for
creasing the stock of flathead along the east Aus-
alian coast.

(iii) *Lakes Entrance Danish Seine Fishery.*—With
e co-operation of the fishermen a regular sampling
under way which is likely to throw light on whether
not the stock of flathead is continuous with that
isting on the New South Wales coast.

(*h*) *Jack Mackerel* (Trachurus novae zelandiae).—
rom July to September, 1952, jack mackerel was plen-
ful, and the catches were greater than the total for the
evious three years. The large catches indicate a
rong year-class which should dominate the fishery
r several years.

(*i*) *Spanish Mackerel.*—Field investigations were
ain carried out in north Queensland during August
December, supplementing observations made during
e spawning season of 1951. Further data on growth rate have been assembled and a large series of otoliths was collected. An analysis of stomach contents and feeding habits has been made.

(*j*) *Echo-sounder and Detection Instrument Developments.*—Test runs were made with an echo-sounder on one of the trawlers of the Red Funnel Company on the New South Wales coast; no shoals were, however, recorded. *Derwent Hunter* also obtained no evidence of shoals between Sydney and Eden, but one of the largest shoals recorded on a echo-sounder in Australia was traced off Eden and proved to be small jack mackerel. These results suggest that on parts of this coast shoals may not be easily detected by echo-sounder, as indeed has been found for some areas fished by English fishing vessels.

Two unsuccessful trials were made in conjunction with the Division of Electrotechnology with an oscilloscope connected to the echo-sounder of a trawler of the above-named company. A subsequent test in a naval vessel proved satisfactory, a piked dogfish 19 inches long being clearly observed on the screen down to 60 fathoms.

Using a directional hydrophone and high-frequency amplifier, preliminary underwater tests were made to find whether the penaeid prawn, *Metapenaeus macleayi,* could be detected by sound, hence aiding its survey. No unusual sound was heard when the hydrophone was only 5 feet from the bag of a net containing 300-400 prawns.

5. ESTUARINE FISH.

(Division of Fisheries.)

(*a*) *Mullet* (Mugil cephalus).—A total of 964 mullett was tagged for the year in south Queensland waters, the percentage return being 2.44. This compared favorably with the return of 2.5 per cent. for the previous year when a similar number was tagged, thus indicating the existence of a stable mullet fishery in the Moreton Bay area. Four fish were recaptured at distances of from 60 to 160 miles north of the tagging locality. They were mature fish and were retaken during their spawning run, thus indicating that the mullet of Moreton Bay do contribute to the catch taken further north during this period.

In an effort to determine the extent of the north coastal migration, the distance from the surf zone of the travelling schools, and the gonadal condition during migration, the possibilities of drift netting with 900 yards of 3¼-in. linen mesh were investigated. It would appear that this method might be used profitably, in particular for mackerel, using a larger mesh size net.

(*b*) *Barramundi* (Lates calcarifer (*Bloch*)).—Preliminary investigations were made on the biology of the giant perch or barramundi. A number of small specimens were tagged in the salt, estuarine, and fresh waters in the vicinity of Rockhampton. Fair early returns included one from a fish which had grown 12 centimetres in two and a half months, and migrated 80 miles to the Fitzroy River.

A number of fish has already been tagged and placed within a freshwater lagoon in the Rockhampton area. Their growth rate is to be noted and compared with scale-reading results. Stomach contents of smaller fish from freshwater revealed a mixture of plant and animal detritus, the latter consisting of aquatic insects, small crustaceans, and small fish fry. Stomachs of larger forms, however, contained mullet, bony bream, prawns, small perch, freshwater jew, and eels. Spawning takes place in coastal waters at a time closely approximating the wet season—during the period November to January.

Barramundi mature when approximately 17 lb. in weight and 33 inches (84 centimetres) in length. Scale-reading results indicate that such barramundi might be two years old. After spawning the mature barramundi remain within the limits of the continental shelf in coastal waters or river estuaries. Young barramundi migrate upstream from estuaries. They survive, in the river headwaters, in holes when the rivers dry back. Holes which will dry up during a prolonged dry season are avoided.

(*c*) *Black Bream* (Mylio australis (*Gunther*)).—Work has been concentrated on the collection of material from the Sydney and Brisbane fish markets. Studies have included: size composition of commercial catches, length frequencies and scale sampling, gonad and stomach content collections.

(*d*) *Fish Culture.*—Of the two fish culture experiments started, one was unfortunately ruined. The sand barrier to the ocean of the Moreton Island lagoon was penetrated during a period of high tides and strong south-east winds, and the lagoon became useless for experimental purposes. However, much useful information had already been obtained on the transportation of small fish fry, particularly *Mugil cephalus,* from the small creeks and estuaries around Moreton Bay to the lagoon. Some 10,000 fish fry, mainly sea mullet, but including whiting, were transported by tanks, in which the water was changed about every hour. Large shallow tanks, 6 by 3 feet by 1 ft. 6 in. were most satisfactory, the carrying capacity of such tanks being 1,000 1-2 in. mullet or about 400 small whiting. The mortality rate remained below 10 per cent. if the water was renewed every hour. The fry were obtained by means of mosquito netting, strung between two poles, from shallow, muddy-bottomed creeks. These fry would appear to swim up such creeks when open to bay waters during high tides and to remain there until the next set of high tides under conditions of low oxygen content and high temperatures.

A paper on the hydrological and plankton cycles found in the lagoon for the eighteen months prior to the break through is almost complete.

Construction of another fish farm for the culture of mullet fry in Moreton Bay is now under way.

The other fish culture experiment at Maianbar is proceeding. A preliminary study has been made of the physico-chemical and biological properties of bottom muds, and of the changes induced by organisms in these muds and the supernatant water.

It has been found that diatoms are an important food of the mullets, which are equipped with a strongly muscular stomach using mud particles to grind up the diatom tests. It has been possible to differentiate between the epiphytic and mud diatom floras and thus to follow the feeding habits of mullet. It can now be shown, by determining diatom species found in their stomachs, where mullet have been feeding, irrespective of where they may be caught. This is useful in following the movements of the fish in estuaries, e.g., from flats to deep holes and from one part of an estuary to another. This method of study is applicable to small as well as to large fish. A preliminary survey has been made of the diatoms of a number of estuaries from Lake Macquarie to the Gippsland Lakes.

The mud, which under shallow water determines the properties of the supernatant, forms a strongly reducing environment. At first this was thought to be a purely microbiological phenomenon, but it appears that a strongly reducing substance is present in *Zostera* and that this can reduce sulphates to sulphides, as well as produce a reduction potential comparable to that of molecular hydrogen.

Direct bacterial counts have shown that turbulence i the intertidal and subtidal zones of estuaries causes a increase in the bacterial count of the water, and count at depths to 3 feet in the mud confirm the theory of th vertical movement of water in the intertidal flats.

Hydrogen ion and redox potential changes have bee correlated with sulphate reduction, which has been an is a subject of special study. *Microspira* is omnipresen in estuarine muds and even occurs in the sand of ocea beaches. It is accompanied by a commensal aerobe an by thiobacilli which oxidize the sulphide formed b *Microspira.* Under certain circumstances sulphur i produced.

It has also been found that most aerobic bacteria i sea-water and mud will utilize calcium phosphate an ferric phosphate. This occurs through bacteria fermenting galactose, mannitol, and other carbohydrate common in seaweeds and reducing the pH from 8.1 t 5.3, thus causing the dissolving of phosphates. Thi action is apparently confined to the micro-environment Even if the pH is buffered at 8.5, phosphate is stil dissolved. Presumably ferric and calcium phosphat are sufficiently soluble to form a continuous reservoi for the bacteria.

Little work has been done on the nitrogen cycle, bu *Azotobacter* has been isolated from the muds.

6. Freshwater Fisheries.

(Division of Fisheries.)

(*a*) *Trout Investigations* (*Tasmania*).—Work continued on the lines of the previous year.

(i) *Lake Leake.*—The study of the spawning run i 1952 showed that brown trout ran intermittently fro 5th May until 28th June, depending on local rainfall i the catchment area. During this time some 1,100 fis were handled, though some escaped owing to floods.

(ii) *The Great Lake.*—The spawning run of th brown trout at the Great Lake lasted from 17th Apri until 14th August, during which time 1,900 fish wer handled. The rainbow run lasted from 14th September until 8th November, and 845 fish were handle The condition of the fish in this lake showed a furthe falling off from the values of the previous year, and, a forecast, the fishing during the following season wa disappointing.

(iii) *The Plenty River.*—The spawning run o brown trout passing through this fish trap allowed o the handling of 560 fish between 20th April and 28t June. The fish passing the trap are of interest in tha it is possible to distinguish, by means of scale examination, two groups of fish; those that have spent all thei life in the river, and those that have visited the estuar on one or more occasions, when an increased rate o growth occurred.

(iv) *Rivers of the North-west.*—Reliable data o catches are being sought from these rivers to establis the extent of the spawning runs, the extent of the spawning beds, and the survival from natural spawning.

The outstanding result of a recent official visit to Ne Zealand, made under the auspices of the Salmon an Freshwater Fisheries Commission, was the adoption o the recommendations made in a private report; thi should enable a programme of trapping rivers to b started in a very modest way. It is desirable not only t trap the fish running for spawning and on their retur from the headwaters, but also to install traps to asses the extent of the downward migration of yearling fis from the upper waters.

(*b*) *Freshwater Fish Culture* (*Tasmania*).—(i *Lake Dobson.*—The results of experiments in this lak aimed at increasing productivity, are about to be published. Fertilization resulted in increased water-wee growth, carrying a rich epifauna. Trout have bee introduced.

(ii) *Deloraine.*—The study of an artificial lake, contructed over a year ago, near Deloraine, has been coninued. The grass which covered most of the bottom has ow decomposed, giving way to a large extent to freshater vegetation, partly introduced. In April, 1953, ,827 yearling brown trout were introduced.

(c) *Fish—other than Trout (Tasmania).*—The uropean perch (*Perca fluviatilis*) and tench (*Tinca ulgaris*) which were introduced into Tasmania in the 860's were selected as suitable types of fish for possible tocking of more stagnant waters. Their growth rates re being studied. Because of the difficulty of obtaining ufficient numbers for stocking an attempt is to be made o build up a breeding stock of these two species at the lenty Hatcheries.

7. CRUSTACEA AND SHELLFISH INVESTIGATIONS.

(Division of Fisheries.)

(a) *Western Australian Crayfish* (Panulirus longpes).—The total catch for 1952 was 8,500,000 lb., an ncrease of 1,500,000 lb. over 1951, due to an extension f the fishery north and south of the area fished in 1951. t is now evident that the accumulated stock on areas djacent to the coastal processing stations and freezer oat anchorages has been removed. Thus the catch in he Abrolhos area shows a decline in total catch (1950, ,100,000 lb.; 1951, 1,650,000 lb.; 1952, 1,550,000 lb.). he numbers of fishermen operating were less (1950, 14 men; 1951, 94 men; 1952, 84 men), but the catch er man increased and the fishing effort was more evenly pread over the fishing season (April-August inclusive).

The analysis of the data of the continuous fishing ests of 1947 and 1948 and of the progress of the brolhos fishery for the ten years 1943 to 1952 has been ompleted. A continuous test replicating that of 1948 nd combined with a marking experiment, at the estern reef of Pelsart Group, Houtman's Abrolhos, as commenced in March, 1953. The returns for arch and April were approximately two-thirds of hose for the corresponding period of the test of 1948. his relation is very closely that existing in coastal reas which have been intensively fished from 1948 to 952.

A detailed investigation of the "white crayfish" ccurrence in coastal areas was carried out during ecember. Experiments and observation show that it s evident that these crayfish represent a phase in the ife history of crayfish which have developed in the oastal limestone reefs, the phase being the ecdysis efore gonad maturation. The migration following on his ecdysis appears to be due to changes in the bottom ater temperatures of the southern coastal reef areas, ombined with nutritional needs for full maturity.

Biological surveys were continued in the area, Cape aturaliste to Hamelin Bay, in the south-west of estern Australia, a distance of about 90 miles. pawning crayfish and crayfish in the white crayfish hase, all of *Panulirus longipes*, were obtained. The arapace length range agreed with that found elsehere. This indicates that these occurrences are not he result of a southern accumulation of large crayfish ut are probably due to normal development and growth ithin the area.

The total area over which this species is now known to ccur under conditions of average growth and developnent is one extending seawards to about 30 fm, and orthwards about 500 miles from Cape Leeuwin. The egion of optimum growth and development is that xtending from Garden Island in the south to Port regory in the north.

(b) *Prawns.*—Preliminary biological surveys were nade in north-west waters of Western Australia. The reas yielded samples of the tiger prawn (*Penaeus esculentus*) and a species allied to the king prawn of New South Wales (*P. plebejus*), in addition to several others. Surveys will continue in Shark Bay and Exmouth Gulf in 1953.

(c) *Oysters.*—A survey of the oyster-growing potential of the east coast of Australia has been commenced. Fourteen stations have been established ranging from Maryborough in Queensland through New South Wales to Mallacoota in Victoria. In addition, seven substations have been established in Moreton Bay. Each experimental plot is maintained by a local commercial oyster-farmer.

Spatfall observations have continued in the Moreton Bay area. The heaviest spatfall at Dunwich occurred in December for the third year in succession. Using fibro-cement as experimental spat catchers, results up to 2,000 young oysters/square foot were obtained.

(i) *Japanese Oysters.*—Seventy-five cases of Pacific seed oysters (*Ostrea gigas*) were air-freighted from Japan to Pittwater with negligible mortality. It is hoped that the survivors of the 2,000,000 young oysters will provide the brood stock that will establish *Ostrea gigas* in Tasmania.

The Pacific oysters showed great resistance to the effects of freshwater flooding. After heavy rains it was found that 100 per cent. mortality occurred in the Sydney rock oyster (*Crassostrea commercialis*), the Stewart Island oyster (*Ostrea sinuata* Lamarck), and a euryhaline paragraspan crab. The Pacific oyster survived the abnormal conditions with a complete absence of mortality.

At Port Sorell, where thermal graphs give greatest hopes of suitability for mass spawning, a drift-bottle programme has been completed to find a site from which larval stakes of the Pacific oyster will not be swept out to sea and lost. Several pools between Rabbit Island and the township of Port Sorell have been surveyed with the idea of turning them into spatting tanks if natural methods fail.

(d) *Scallops.*—Diving investigations have proved of great value in effecting population studies and noting changes in density distributions. Sufficient data have now been collected to interpret and predict changes in the fishery.

It has been found that the "condition" of the scallops is dependent on the trend of temperature changes in the waters of the D'Entrecasteaux Channel four to five months prior to the opening of the season. Diving has proved that beds of juvenile scallops do not move from the area on which they first settle. Under satisfactory conditions, the commercial scallop takes five years to reach the minimum legal size, but during the last three years of this period the population may be reduced by 60 per cent. by starfish predation. The large eleven-armed starfish *Coscinasterias calamaria* (Grey) is thickest on the beds of juvenile scallops, and reduction in its numbers may yet become necessary.

(e) *Pearlshell.*—Further biological data on all species of pearlshell were collected, surveys were made of new and previously known pearling beds by the *Gahleru*, and pearl culture experiments were commenced.

The expected summer spat-sets of *Pinctada vulgaris* and *P. sugillata* were observed, but they were lighter than in the previous year; in particular that of *P. vulgaris* was very light. No explanation is put forward for these phenomena. Special attempts to obtain sets of *P. maxima* were unsuccessful.

Evidence is now to hand of a set of *P. margaritifera* in Thursday Island harbour towards the end of 1951. A number of young specimens were taken from the hull of a vessel moored in the harbour from June, 1951, to December, 1952. Other specimens of a comparable size were found on wharf piles. This is the first set of this species in Thursday Island harbour in four years.

To summarize the spat-setting observations it seems that the density and regularity of set is definitely correlated with the size of the stocks of adults. *P. vulgaris* and *P. sugillata,* which exist everywhere in great numbers, set regularly and heavily. *P. margaritifera* and *P. maxima,* which are very scarce, set lightly and intermittently.

8. ICHTHYOLOGY.

(Division of Fisheries.)

(*a*) *Reference Catalogue of Australian and New Guinea Fish.*—A considerable amount of data has been incorporated in the card index of Australasian fish. This has been brought up to date with a total of 2,704 species, completely covering the known fauna. A further 550 illustrations have been located, and with the insertion of these a figure will be on file for every species which has been illustrated in literature. All more important papers on Australian fishes have been extracted for incorporation in the synonymy and an examination of the balance of minor publications is under way. The cross-index to generic and specific names is completely up to date and a cross-index to common names is partly prepared.

(*b*) *Check-list of Fishes of New Guinea.*—As part of the Division's investigation of the fish fauna of New Guinea, an exhaustive annotated check-list has been prepared of the fishes recorded from Papua, New Guinea Trust Territory, Bismarck Archipelago, and the Solomon Islands. For completeness in the treatment of a natural area, the records from Dutch New Guinea, Waigeu, and Misool are incorporated. The manuscript incorporates modern nomenclature and was compiled direct from the original works. A bibliography of the ichthyological literature of the area is incorporated. The work is complete except for final rearrangement and typing in a form suitable for publication.

(*c*) *Handbook of Ceylon Fish.*—A completely referenced check-list has been compiled for the Ceylon fish fauna. Work was carried out primarily during an official secondment to the Ceylon Government under the Colombo Plan and completed at Cronulla. It is available for publication as an ordinary check-list or as a basis for an illustrated and keyed handbook of the Ceylon fish fauna.

(*d*) *Revision of Australian Clupeoid Fishes.*—Further collections of adult and larval fishes have been assembled for a monographic treatment of the taxonomy and larval development of Australasian species. The types of some species were examined in the British Museum.

(*e*) *Report on Antarctic Fishes.*—Further small collections of fish from Heard Island, Macquarie Island, and Kerguelen have been received from the Australian National Antarctic Research Expedition. They will be incorporated in a report at present being prepared on fish material submitted from all expeditions to the Antarctic since 1948. Some comparison was made with material collected by the Norwegian Whaling Expeditions, now in the care of the University of Oslo.

9. HYDROLOGY.

(Division of Fisheries.)

(*a*) *Oceanic Investigations.*—(i) *Co-operation with the Royal Australian Navy.*—Permission was secured for oceanographical equipment to be placed on H.M.A.S. *Barcoo* and some valuable data have bee collected in the course of her naval duties. Thi supplements knowledge of conditions in eastern Au tralian offshore waters.

(ii) *Surface Tasman Sea Collections.*—By kind pe mission of the Huddart Parker Company, and wit the co-operation of the engineers of T.S.M.V. *Wang nella,* regular fortnightly collections of surface wate samples for salinity and temperature determinatio have been made since January, 1953, whilst *en rout* from Sydney to Wellington or Auckland. Some exce lent information has thereby been secured.

(*b*) *Coastal Studies.*—(i) *South-east Australia Waters.*—A paper dealing with some aspects of th long-term trends in properties at regular stations, an another on the latitudinal variation in productivity are in preparation. By using drift cards instead o bottles at coastal stations the number of releases an returns and the statistical reliability of results ar very greatly increased.

(ii) *Bass Strait.*—A sampling programme has bee developed in Bass Strait and adjoining waters in orde to throw light on the circulation and productivit characteristics of this area, which seems to form a environmental barrier to the east-west movement o fish stocks.

(iii) *South-west Australian Waters.*—The Gerald ton-Abrolhos line of stations was discontinued in orde to allow of a more thorough monthly investigation o the 50 metre coastal station west of Rottnest Island The temperature range of 4° C. found is relativel small, and a maximum thermal gradient of 2° C contrasts sharply with much higher gradients whic are encountered along the eastern Australian coast Maximum temperatures were observed during th autumn months, after which there was a stead decrease to the minimum of 18° C. in November There was a sharp drop in the salinity of the whol water column in June. Throughout the winter an spring the salinity rose steadily and high concentra tions of organic phosphorus were detected throughou the entire water column. The steady drop in wate temperature from June to November indicates tha this water mass originated westwards in the deepe waters.

(*c*) *Estuarine Investigations.*—(i) *Productivit Studies.*—Effort is now being concentrated on a stud of the probable factors controlling the availability o certain nutrients in deep basins of some New South Wales estuarine systems.

(ii) *Lake Macquarie Survey.*—In June, 1953, th hydrological section of an ecological survey of Lak Macquarie began. Attempts will be made to measur the flushing rate of the system and the rate at which pollution loads will be diluted by marine exchange.

(iii) *Shell Point* (*Oyster Experimental Lease*).—Studies on the circulation of water and thermal charac teristics in the intertidal region have been continued To determine the exact distribution of chemical properties beneath the mud surface, cores of 20-24 inche depth have been collected and analysed for the usua constituents; this has revealed the upward displacement by about 6 inches of the superphosphate originally added at 12 inches beneath the surface. To explore subsurface water movements a series of manometer registering the water pressure at various depths beneath the mud surface, and sited at mid-tide, low-water and fully submerged levels, has been put into operation. To estimate the rate of lateral movement in the development of the observed pressure pulses, a duplicate set of manometers, enclosed in 4-inch piping extending down to a depth of 4 feet, has been installed and are read simultaneously with the original.

(iv) *South-west Australia.*—A more intensive study s made of the discharge and recovery period in the an River. Salinity and oxygen saturation values ried in such a way to suggest that desaturated water high salinity, originating in the deeper waters of basin during rainfall discharge, were forced into shallower waters at the upper end of the basin to replaced subsequently by water of a lower salinity d higher oxygen saturation. Future work must empt to elucidate the mechanisms responsible for s oscillatory effect. The generation of inorganic osphate in the bottom waters of the basin was even re intense than in 1951, with a maximum value of μg. P/l. at the height of stratification. Hypotheses ve been developed to explain the high phosphate ncentrations and tests to evaluate these theories will initiated.

(*d*) *New Investigations.* — (i) *Radiochemical udies.*—The instrumental difficulties involved in the plication of the trace technique to problems of osphorus metabolism in estuarine muds, have now en solved and an experiment is in progress designed show the rate at which, or at least the possibility at, vertical water movements in a typical estuarine ud profile could contribute to the vertical movement phosphate.

The possibility that diurnal pH changes in the estern Australian coastal waters could be a major ctor in the development of certain features of estern Australian coastal limestone reefs is also being vestigated by the tracer technique.

The ^{14}C technique for the estimation of carbon similation in the sea has received some preliminary amination and it is hoped that in the near future is method will be applied to eastern Australian ters and provide a further check on the independent imates of productivity based upon nutrient and lorophyll cycles.

(ii) *Spectrophotometric Determination.*—In study- g the productivity cycle of the sea it is essential to ow what quantities of phytoplankton are available r the assimilation of inorganic nutrient, and their act lateral and depth distribution. A chemical ethod was therefore devised for the estimation of ytoplankton densities, adopting the spectrophoto- etric method developed overseas, which utilizes the aracteristic absorption bands of plankton chloro- yll. Preliminary tests on the efficiency of various lvents in the extraction of chlorophyll, on the rela- nship between chlorophyll and total organic matter the cell structure of typical algae and diatoms, and field collecting practices were begun.

It is proposed also to estimate with the spectrophoto- eter the seasonal cycle of ferrous-ferric iron and some her trace elements in estuarine and coastal waters.

10. Plankton Investigations.

(Division of Fisheries.)

A limited programme of plankton study was main- ined in association with hydrological work. A system reliable fractionation of samples, employing an im- oved "whirling" instrument, was introduced to inimize the effort of counting of organisms in the tches.

Work was done in the Bass Strait area, the Thursday land pearlshell investigations, and the survey of the ew Guinea fishery environment. The study of the stribution of euphausiids (Crustacea) in the Western ustralian area has been continued. The three major ecies are *Euphausia hemigibba* as a slope and ocean ecies extending from North-west Cape in the north Albany on the south coast; *E. recurva* as a slope and elf species from Shark Bay to Cape Naturaliste; and *seudeuphausia latifrons* as a shelf, on-shore, species tending along the coastline of the State.

11. Other Investigations.

(Division of Fisheries.)

(*a*) *Fouling.*—Results so far obtained are recorded in two papers now in the press; a third paper is in preparation. Visits were paid by request to the Naval Establishment, Garden Island, and to various Sydney power houses, to advise on fouling problems. The Underwater Paints Committee, formed at the instigation of the Royal Australian Navy, held four meetings. The Committee requested continuation of the fouling programme of the Division.

A rotor-tester has been devised by this Division and has been installed at White Bay power house. It has been found that diatoms and algae attach at speeds up to 16 kt., while barnacles (*Balanus amphitrite*) attach at 2.05 kt. and tube worm (*Hydroides multispinosa*) at approximately 1.6 kt. These results suggest that fouling can be controlled by maintaining the rate of flow continuously, even at off-peak periods; chlorine or sodium pentachlorphenate can be used when the flow falls below the critical value.

(*b*) *Fish Eggs and Larvae.*—Experimental work on the rearing of fish eggs and larvae progressed, some success being achieved in the carrying through of larvae to more advanced stages. The feeding of larvae has been investigated overseas and some preliminary tests with brine-shrimp nauplii and unicellular organisms have been carried out. The development of the flying fish (*Hirundichthys speculiger*), sabre-toothed blenny (*Dasson steadi*), viviparous blenny (*Sticharium dorsale*) and Leftwich's goby (*Youngeichthys leftwichii*) have been investigated and accounts are being prepared. The eggs of a number of tropical and sub-tropical fish have been obtained from mature adults and work has commenced on the description of these for publication.

(*c*) *Aquarium.*—As the result of a study of overseas practice a new pumping unit has been installed and re-designed reticulation is planned, which will improve the quality and the quantity of the sea-water supply.

XIII. FOOD.

1. General.

The processing, preservation, and transport of foodstuffs is of great importance to Australia as a food-producing country, more particularly as it is situated inconveniently far from the main food-importing nations of the world and its own population centres are separated by long distances. The Organization's work on food is undertaken chiefly within the Division of Food Preservation and Transport with its main laboratories at Homebush, New South Wales, and branch laboratories at Brisbane, Queensland (meat); West Gosford, New South Wales (citrus fruit); Eden, New South Wales (fish); Hobart, Tasmania (fish, apples, and berry fruits); and at the Biochemistry Department, University of Sydney (physical chemistry). The work of the Division is described in Sections 2 to 11 of this Chapter. Work on the manufacture of dairy products is carried out by the Dairy Research Section at Fishermen's Bend, in Victoria (*see* Section 14 of this Chapter). Work on dried vine fruits is in progress at the Commonwealth Research Station (Murray Irrigation Areas), Merbein (*see* Section 12 of this Chapter). Co-operative investigations on wines are carried out in the Waite Agricultural Research Institute (*see* Section 13 of this Chapter).

Division of Food Preservation and Transport.—The first post-war consignment of chilled beef from Australia to Great Britain was shipped from Brisbane in May, 1953. The techniques for the preparation and cooling of the meat were developed by the Division in the years 1932-39 and were applied and supervised by the Division's officers. Since the co-operative investigations on frozen beef are occupying a major part of the time of the Division's Brisbane laboratory staff, research studies on chilled beef have had to be restricted. If the chilled beef trade shows signs of resuming its pre-war importance, these research studies will be accelerated.

The fruitful co-operation of the Biochemistry Department of the University of Sydney with the physical chemistry group continued during the year. An officer has initiated a course of lectures and demonstrations on the physical chemistry of proteins for senior students in biochemistry. It is hoped that this course will stimulate graduands in the Faculty of Science to post-graduate interest in problems of protein chemistry which are of importance in the food and pastoral industries. The Specialized Instruments Corporation quantitative refrigerated ultracentrifuge was installed in an air-conditioned laboratory generously provided by the Cancer Research Fund of the University of Sydney. This ultracentrifuge, which is the only one of its type in Australia, will be of considerable value to University workers in their enzyme and serum protein studies and to the Organization's workers in their fundamental studies on the denaturation of proteins.

The wide knowledge of the processing and preservation of various foodstuffs now possessed by the Division's officers is being increasingly utilized through technical inquiries from Government Departments and industry. During the year two special surveys of the handling and preservation of marine products were conducted on behalf of State Departments. At the request of the Chief Secretary's Department of New South Wales, a survey of the nature and extent of wastage in cooked prawns was commenced. A survey of the Victorian Fishermen's Co-operative cold stores and their operation was carried out at the request of the Victorian Department of Fisheries and Game.

As the result of the interest stimulated in the United States of America in 1952 by a report on the Division's work on crops of peas intended for canning, the two authors were invited to be guest workers at the New York Agricultural Experiment Station. Both officers were able to accept this invitation, the visit of one of them being made possible through the generous support of several Australian vegetable-canning firms.

Dairy Research Section.—Milk production in Australia is not expanding, while local consumption of all dairy products continues to increase. With the aim of attaining maximum advantage from the dairy industry from the view-point of food resources, the Dairy Research Section deals with some of the longer-term and more specialized problems in dairy products manufacture, with research directed increasingly towards improving the efficiency of milk products processing and the initiation and development of means of using all the milk solids as human food.

With the temporary accommodation which had been generously provided for officers of the Section at the School of Dairy Technology, Werribee, and the Bread Research Institute, Sydney, no longer available, laboratory space at Fishermen's Bend has been severely strained. A prefabricated building at Highett is, however, approaching completion, and tenders have been called for the larger permanent buildings on that site.

2. PHYSICS.

(Division of Food Preservation and Transport.)

(*a*) *Rail Transport.*—Studies of the performance of refrigerated rail cars, mainly in collaboration with officers of the New South Wales Railways, have been going on for some years. These have the double pu pose of obtaining information on typical cargoes an at the same time, investigating the heat transfer pr cesses in the cars to provide a sound basis for conside ing new developments in the design and operation vehicles. Among the cargoes studied this year we thoroughly precooled fruit on a long journey and be which had not been thoroughly chilled before loading

(*b*) *Evaluation of Canning Processes.*—In a can food there is usually an air space between the top the food and the top of the can. The effect of th headspace on heat penetration during processing h been investigated. The rate of heat penetration throug the headspace is low, typically 7 B.T.U./ft.^{2} hr. ° under ordinary processing conditions. Consequent the slowest heating point of a solid pack is not at i centre but appreciably above it and the relative di placement of the slowest heating point from the cent is greater in a squat can than in a tall one. Negle of the thermal resistance of the headspace wou cause serious errors in calculating processes from fir principles or in estimating equivalent processes f cans of different shapes, but it does not appreciab affect the calculation of processes from heat penetratio measurements. Factors affecting the lag factor or value, used in specifying heat penetration into can have also been studied.

(*c*) *Design and Performance of Cold Stores.*—Tl experimental work on a survey of the performance representative Australian fruit cool stores was term nated last year. The accumulated data have bee analysed and are being used in the design and operatio of cool stores. Studies of the performance of stor at freezing temperatures have been started.

(*d*) *Water Relations.*—Work on the determinatio of equilibrium humidities and the relation betwe the equilibrium humidity and water content of pa ticular materials is continuing. When dried vi fruits are held in a dry atmosphere the approach to true equilibrium may be very slow and the significan of experimentally determined vapour pressu isotherms is therefore somewhat doubtful. Observ tions at temperatures in the range 20-50° C. ha shown that the rate of losing water decreases rapid with decreasing temperature. It is very low at 20° and even after twelve months an appreciable quanti of water can be removed by raising the temperatu to 50° C. Still more water is removed in the standa oven determination at 70° C.

(*e*) *Colour Measurement.*—Instruments are bei designed and tested for obtaining a precise objecti measurement of the changes or differences in colo which are important in particular storage or processi investigations.

(*f*) *Cavity Ice.*—When packaged frozen foods a held in cold storage, ice crystals tend to accumulate cavities in the pack. This ice comes from the foo itself, and with some products the evaporation whi produces it may be enough to cause severe freez burn, which is an irreversible dessication of parts the surface of the foodstuff. The physics of cavity i formation is being studied with the object of assessi the relative importance of features in the design a handling of the packages.

(*g*) ***Freeze Drying.***—Modifications of the laborato equipment and investigations of the processes of free drying of foods and biological materials have bee carried out to increase the usefulness of the laborato freeze driers as experimental tools.

(*h*) *Evaporation from Fruit.*—Further work h been done on the relation between the rate of evapor tion from pears and the drying power of the stora atmosphere.

3. Food Chemistry.

(Division of Food Preservation and Transport.)

(*a*) *Destruction of Ascorbic Acid* (*Vitamin C*).—
e studies on the anaerobic destruction of ascorbic
id are related to the loss of ascorbic acid from
nned foods in which virtually anaerobic conditions
e established within a short period after canning.
udies of destruction at 30° C. over a period of two
ars were completed and the results prepared for
blication. The effects of pH, fructose, sucrose, and
ctose-1,6-diphosphate were investigated and con-
ered in relation to the retention of ascorbic acid by
it and vegetable products. The yield of furfural and
rbon dioxide as products of decomposition was inves-
ated. Work was also done on the decomposition of
hydroascorbic acid. Glucose, fructose, sucrose,
rch, pectin, and oxalic acid were without effect.

(*b*) *Volatile Products of Apples.*—There is evidence
some relation between volatile substances and super-
ial scald, a functional disorder. Preliminary experi-
nts last season gave some indication of a relation
tween free volatile acids and superficial scald. Oil-
apped apples are being exposed to low concentrations
volatile acids and esters, and the individual free and
erified acids are being determined in peelings.

(*c*) *Natural Coating of Apples.*—The studies on the
tural lipoid coating of apples are related to the
ysiological behaviour of stored fruit, as the natural
ating is the main barrier to gaseous diffusion and
nce influences the composition of the internal atmos-
ere. The chemical constitution of the oil fraction
being investigated. A preliminary separation was
dertaken of the fatty acids and neutral substances
tained by saponification. The fatty acids were
parated by fractional distillation of methyl esters.
e use of the refractive index-density diagram in
nnexion with this distillation is being developed.
e neutral substances were separated by distillation
d adsorption and shown to include hydrocarbons,
ohols, and other compounds. A larger quantity of
is being obtained for study in the present season.
e separation of fatty acids by partition chromato-
aphy on powdered rubber, and the separation of
ohols by adsorption chromatography of the coloured
enylazophenylurethanes were also investigated. A
rther study of the insoluble "cutin" is being made.
moval of cell wall material with snail cellulase is
der investigation.

(*d*) *Determination of Ethylene Dibromide in Air.*—
hylene dibromide is used for fumigating citrus to
stroy fruit fly infestation. A rapid method of deter-
ining ethylene dibromide in air was developed.

(*e*) *Determination of Diphenyl in Fruit Wraps.*—
terminations were made in connexion with citrus
rage experiments. A source of error was found in
e published spectrophotometric method, and a modi-
d method was adopted.

(*f*) *Chemical Reactions in Processed Foods.*—The
udy of the chemical composition of certain raw
uits was continued. This work forms a necessary
sis for the investigation of the reactions involved
the browning of fruits when dehydrated and stored.
he amino acids in apricots and peaches were studied
paper chromatography and by displacement chroma-
graphy using columns of ion exchange resins. All of
e major amino acids and most of the minor ones have
en recognized. The carboxylic acids in the same
uits have been separated by displacement chroma-
graphy using anion exchange resins. The major
ids have been isolated and identified and many of
e minor acids have been recognized. A ketose
curring in apricots, which could not be identified by
romatographic methods, has been shown to be an unknown oligosaccharide containing glucose and fructose. Another unknown ketose occurring in pears awaits investigation, but the other sugars in apricots, peaches, and pears have been recognized. The occurrence of a uronic acid, which is probably galacturonic acid, in pears has been found to depend on the method of ripening the fruit. Peach and apricot purées have now been successfully freeze dried and this material is being allowed to brown at a suitable temperature and moisture content. The chromatographic techniques developed can now be applied in the study of the chemical composition of this material before and after browning.

(*g*) *Protein Chemistry.*—(i) *Determination of Total Nitrogen in Proteins.*—A critical study has been made of the digestion of amino acids and proteins with sulphuric acid. The effects of temperature, catalyst, and oxidizing agent have been specially studied.

(ii) *Studies in the Denaturation of Proteins.*—The denaturation of certain enzymes and proteins by heat, freezing, and urea is being examined. The general aim has been to study the process by following simultaneously the changes in several properties which are sensitive to different kinds of deformation of the protein structure. Special attention is being paid to the solution, viscosity increment, solubility, and ability to combine with heavy metals.

(*h*) *Infra-red Spectroscopy.*—The infra-red spectrograph has been modified during the year and has recently been equipped with a vacuum system for continuous evacuation thermocouple detector. Studies in protein chemistry and on the structure of limonin will be materially assisted by this modification.

(*i*) *Polarography.*—(i) *D.C. Instrumentation and Derivative Polarography.*—Lower limits imposed by overseas authorities for trace elements, particularly lead in canned foods, have necessitated improved methods for this analytical determination. The range of the laboratory's existing recording D.C. polarographic equipment is being extended for this purpose. The technique of derivative polarography is being developed, involving the superposition of a square wave of about 10 c/s. generated and rectified by means of choppers.

(ii) *Metal-complex Polarography.*—The D.C. polarography of the complexes of amino acids and proteins with copper, zinc, cadmium, and lead has been further studied. It is hoped shortly to apply the technique of derivative polarography to this field.

(iii) *Organic Polarography.*—The polarography of organic compounds in alcoholic solution has been further examined. With limonin and its derivatives an attempt is being made to extend this work to methanol-benzene solvents.

4. Microbiology of Foods.

(Division of Food Preservation and Transport.)

The effects of various environmental factors on the growth and death of food-poisoning and food-spoilage micro-organisms are being studied. Applied studies have consisted mainly of the diagnosis of spoilage in various products, chiefly canned foods.

(*a*) Clostridium botulinum *Investigations.*—Although types A and B *Cl. botulinum* have been responsible for most cases of human botulism, a number of fatalities have been caused by type E strains, and in almost every case fish was the foodstuff concerned. A study of several type E cultures has been continued, and it has been found that they differ from the A and B types in several respects. As type E strains grow well at low temperatures it was thought that they may have a marine origin, but attempts to isolate them from marine muds have not been successful. A paper on the temperature relations of type A and B strains has been published.

(*b*) *Bacterial Spores.*—The study of these highly resistant forms of bacterial life has been continued. In addition to measurements of heat resistance, experiments have been carried out on the factors which are necessary for germination of the spores, and on the conditions under which the spores are formed. Germination is promoted by low concentrations of several substances and inhibited by traces of other compounds. There are, moreover, considerable unexplained differences between different types of spores both in their requirements for germination and their sensitivity to inhibitors.

(*c*) *Water Relations of Micro-organisms.*—The requirements of representative strains of food poisoning *Staphylococci* and *Salmonellae* have been determined. The data should be useful for predicting the amount of water needed to support the growth of these bacteria in various foods. Studies with other organisms are in progress with the object of ascertaining the water requirements of the various types of food-spoilage organisms, and of the biochemical processes involved in the uptake of water by microbial cells.

(*d*) *Mould Wastage of Stored Fruit.*—These investigations have been suspended until a mycologist is appointed.

(*e*) *Freeze Drying of Bacteria.*—The drying of bacterial cultures from the frozen state is widely used as a means of preserving cultures. Frequently, however, a large percentage of the cells die during the drying process. Various methods for reducing the mortality have been proposed, but the underlying reasons for their success are not understood. Experiments to improve the biological efficiency of the process have been commenced, and designs considered of apparatus in which some physical factors can be measured and controlled during drying. Measurements of temperatures of the product being dried have been made in existing apparatus, and these have revealed some problems which will need to be solved.

(*f*) *Mould Counts of Tomato Products.*—Additional experiments to measure the errors inherent in the standard method of analysis have been completed. In general, the errors have been in accord with those expected for a binomial distribution.

(*g*) *Spoilage of Meat.*—Examples of bone taint in beef have been brought to the notice of the laboratory, and the causal organisms isolated from the spoiled tissues. Although it is rare, this form of spoilage frequently results in total condemnation of affected hindquarters, and the isolated organisms are being studied to determine methods by which spoilage may be controlled.

5. MEAT.

(Division of Food Preservation and Transport.)

(*a*) *Co-operative Investigations.* — (i) *General.* — The co-operation between the Brisbane Laboratory and the Low Temperature Research Station, Cambridge, has been strengthened by the seconding of an animal physiologist and an assistant from Cambridge to work for a period of one to two years at Brisbane.

(ii) *Freezing of Hot Carcasses.*—It seems likely that, if muscle tissue becomes frozen before it passes into rigour, the formation of drip on thawing could be aggravated. Fundamental studies also suggest that holding the frozen carcasses at a temperature just below freezing, just prior to thawing, might offset this effect. Trials are under way to test these questions on carcasses of widely different quality. So far it has been found that only with light weight carcasses is there any possibility that, with existing freezing equipment, an appreciable portion of the carcass will be frozen before rigour occurs. As, however, the biochemical changes preceding rigour will all have been taking plac reduced rates, it is still possible that the early free may have modified the muscle. After a period frozen storage the material will be examined to de mine the extent of the biochemical changes, tendency to drip, and the eating quality.

(iii) *Modification of Muscle of Beasts Pre-slaugh* —Laboratory investigations at the Low Tempera Research Station and at Brisbane have shown that tendency for thawed muscle to drip may be influe both by the calcium-magnesium levels in the mu and by its acidity. Attempts are in progress to b these changes about by controlling the feeding exercise, or by injection of drugs which will alter blood composition. The effect of these treatments be studied by following the development of ri in sections of muscles from the freshly slaught carcasses, and by determining the drip and ea quality of the stored, frozen carcasses.

(*b*) *Chilled Beef Studies.*—A carefully contro and statistically designed experiment has been set to study the extent to which carcasses differ in f quality when subjected to chilling and freezing. initial experiment is to be followed by others in w the time of onset of any such differences will be stu in more detail.

(*c*) *Air-borne Contamination.*—The existence dual humidity-sensitive mechanisms in the destruc of air-borne organisms has now been demonstrate 10° C. as well as at 0° C. The mechanism opera at low humidity has been shown to be a water acti effect. That at high humidity has not yet determined, but several possible explanations, such cold shock and oxygen tension, have been shown t untenable.

(*d*) *Ozone Sterilization.*—A detailed study of dynamics of the decomposition of ozone in the prese of meat has been made in the study of the influenc ozone on the rate of development of organisms on m It has been shown that the decomposition of ozon the presence of meat is a first-order reaction, but reaction constant is a function of the degree of ozonization of the meat surface.

(*e*) *Freezer Burn Studies.*—In the study of dam to frozen offals in storage it has now been shown the severity of the damage to livers is to some ex determined by the fat content, and that it is affected by the period of storage prior to freezing.

6. FISH.

(Division of Food Preservation and Transport.

(*a*) *Analysis of Australian Fish Species.*—Work been carried out on the measurement of the oil con of Tasmanian barracouta at monthly intervals thro out the year. The chief object of this co-opera investigation with the Division of Fisheries was gather information on the changes in oil content w accompany biological changes in the fish. At the s time, data were obtained to explore the possibility using barracouta offal (heads and viscera) for re tion to fish meal and oil. Similar work is being car out with other species. Analyses for urea and methylamine oxide content of various sharks Teleostei have been made. These data will be rel to the various kinds of volatile bases, such as ammo trimethylamine, and dimethylamine, which are duced during spoilage of the various species of fish.

(*b*) *Chemical Methods for Estimation of Spoil* —Further work has been carried out on the meas ment of volatile bases, volatile acids, and vol reducing substances in fresh and bacteriologic spoiled fish muscle and in canned fish and shark w heat-breakdown of urea, or trimethylamine oxide, both has occurred.

c) *Processing Studies.*—The development of monia and trimethylamine during the canning and sequent storage of shark (*Galeorhinus australis*) been studied. Pretreatments of the flesh, such as -soaking in lactic acid, pre-cooking and draining ore canning have been carried out and their effects the development of volatile bases and of off-flavours the finished product have been determined. Attempts ve been made to improve the quality of canned racouta by various pretreatments aimed at reducing masking the intensity of an unpleasant "metallic" our found in the canned product.

7. Eggs.

(Division of Food Preservation and Transport.)

a) *Storage of Oiled Eggs and Carbon Dioxide Gas-red Eggs.*—The analyses of the comparative results the storage of oiled and unoiled eggs with eggs stored carbon dioxide gas mixtures, with respect to the ernal quality observed after cold storage of the eggs, ve been completed. After storage for fourteen weeks, ich is an average period for storage and transport the United Kingdom, there are no appreciable ferences in the internal quality between unoiled, ed, and gas-stored eggs. When the storage period s extended to 26 weeks some advantages in internal lity accrued from the oiling and gas storage. How-r, these advantages must be balanced against the advantage of decreased percentage of thick white in oiled and gas-stored eggs as compared with unoiled s.

b) *Effect of Additives to the Oil.*—Aluminium and gnesium stearates have been added in various con-trations to oil used for coating eggs in order to the possibilities of improving the properties of the ginal paraffinic oil. The internal quality of eggs so ated has been compared with that of oiled and oiled eggs after a period of cold storage.

c) *The pH-Carbon Dioxide Relationship in Egg ite.*—The relation between the pH and the total bon dioxide content of the white of oiled eggs and s stored in carbon dioxide gas has been determined elucidate the reactions controlling the pH in the ite of oiled eggs. Further work has shown that linear regressions of the pH on the concentration carbon dioxide in the white are similar for oiled s and eggs stored in carbon dioxide gas mixtures, icating that the pH change in oiled eggs is largely to the level of carbon dioxide in the white.

d) *Structure of Egg White.*—The thick portion of white has been examined with a view to obtaining uantitative measure of the structural changes occur-g during storage. These changes at present are ected subjectively.

e) *Pink Whites in Stored Eggs.*—A condition nifested by a pink coloration in the white of stored s appears after fowls have ingested certain plants the family Malvaceae. Isolation of a fatty acid sent in these plants is proceeding in order to deter-ne whether it is the cause of this disorder.

8. Fresh Fruit and Vegetable Storage and Transport.

(Division of Food Preservation and Transport.)

a) *General.*—The collaborative work with the Uni-sity of Sydney at the Plant Physiological Research it and with the New South Wales Department of riculture at the Citrus Wastage Research Laboratory continued. During the year work has begun in Botany School, University of Melbourne, where research officer and a technical officer have been tioned to carry out plant physiological and bio-mical investigations in connexion with fruit storage blems.

(*b*) *Plant Physiology and Biochemistry.*—Work on the properties of the cell surface and its absorbing capacity and on the functional particles in the cell has been continued. The electrical properties of the cell surface have yielded some information as to its probable composition, which could not be obtained from chemical investigations alone. The large particles (plastids) which are characteristic of plant cells have been investigated and their structure has been shown to include a surface membrane. A membrane has also been found to occur on the smaller particles (mitochondria) which are characteristic of all cells. In collaboration with the Division of Industrial Chemistry, the thickness of this membrane has been estimated and its permeability to dissolved substances studied. The results so far indicate that its permeability is consistent with a lipoprotein structure.

The occurrence of the enzymes concerned with oxygen uptake in the process of respiration has been established in the particles isolated from beetroot, carrot, and apple tissues. The mitochondria differ in their ionic composition from the surrounding medium and this difference is partly dependent upon the membrane and indirectly dependent upon the metabolism necessary to maintain the structure of the particles.

The sudden rise in respiration, known as the climacteric rise, which occurs about the time of ripening in most fruit, has been investigated in apples and pears. With apples the results of tests over two seasons are consistent with the hypothesis that the increase in respiration is due to the increased demands for protein synthesis and maintenance in cells above a certain size. At the same time, the complex of respiratory enzymes, known as succinoxidase, has been shown to increase. Similar results, interpreted in a slightly different way, have been obtained by some workers in America, using the avocado. Experiments have begun to investigate the corresponding rise in pear respiration.

The study of growth of apple fruits has included an examination of the soluble and protein nitrogen constituents. The amino acids have now been identified and some changes in the relative amounts have been observed. The balance in young fruit is upset by removal from the tree. Some differences were obtained between amino acids occurring in fruits and in dormant twigs.

The synthetic processes are connected with the liberation of energy in the respiration process largely by the specific substances termed phosphate carriers. Estimation of the more important phosphate carriers of plant tissue is important to explain the control, not only of growth, but also of normal cell activity in the resting cells of stored fruits and vegetables. The estimation of these important phosphate carriers is being studied at the Melbourne University Botany School.

The relation of fruit size to cell size and cell number had previously been shown to influence the behaviour of fruits of different sizes in store. Fruits of the Delicious variety grown on the west coast of America and grown in New South Wales have been compared. Preliminary results indicate that the American fruit is larger than the Australian fruit because of a larger number of cells (not a greater cell size) and this probably accounts for their better storage behaviour.

The pea, one of the most important vegetable crops, has a narrow margin of optimum maturity for use either in the home or in commercial processing. The physiology of maturation of peas is being investigated. Experiments have been made in which blossoms have been tagged so that peas of known age could be analysed for cell size and number, protein and total nitrogen, and carbohydrate content. The rapid increase of starch and protein nitrogen during maturation make this material useful for a general biochemical study.

(c) *Technology.*—(i) *Orchard Variability in Apples.*—The work on the apple varieties Delicious and Granny Smith was carried out for five seasons to determine the variability in storage behaviour and its possible correlation with size of fruit, different trees, different orchards, and different seasons. The statistical analysis of the large quantity of data has been carried out by the Section of Mathematical Statistics.

There is evidence that the different stocks on which apple trees are grown affect the storage life of the fruits. The effects of different stocks on storage life of Jonathan and Delicious from the stock trials of the New South Wales Department of Agriculture at Bathurst have been investigated. This will be compared with similar work being done at the Organization's orchard at Stanthorpe, Queensland.

(ii) *Number of Days to Maturity.*—The results of the experiment to test whether the number of days from full blossom is the best criterion of maturity for picking apples for long storage indicate that the method is not better than the recommended method used in most districts of Australia, which is the change in ground colour of the fruit.

(iii) *Temperature of Storage.*—With the better control of temperature now possible in commercial stores, fruit may be stored nearer to its freezing point with much less risk of actual freezing. This results in a marked improvement in storage life of many fruits. With the apple varieties Granny Smith and Delicious significant differences have been obtained in the storage life at temperatures of 30°, 32°, and 34° F.

(iv) *Superficial Scald in Apples.*—Superficial scald is troublesome in Australian Granny Smith apples, particularly in Western Australia. While this disorder is generally controlled by the use of oiled wraps, it is desirable to know whether fruit which will develop scald can be detected prior to the appearance of the marked symptoms. The cells in the immediate region of the skin are being studied microscopically to determine whether any changes can be detected in incipient scald.

(v) *Delay before Storage of Pears.*—Many Australian districts find difficulty in obtaining rapid storage and cooling of pears after picking. This led to an investigation of effects of delay and rates of cooling on respiration and storage life of both William Bon Chrétien and Packham's Triumph pears. The effects of a given delay can now be defined fairly precisely for these two varieties. Picking at the optimum maturity is of great importance and, once cooling has started, it should be as rapid as possible.

(vi) *Rotting in Winter Cole Pears.*—Investigations of the conditions leading to attack by blue and grey mould in Winter Cole pears has shown the importance of careful handling. Careless handling results in injury at the stage where fruit is exposed to mould infection in the packing houses.

(vii) *Storage of New Varieties of Stone Fruits.*—Investigation of the storage life of new varieties of peaches, nectarines, and plums grown on the Bathurst Experimental Farm has been continued.

(viii) *Orange Storage.*—In the citrus wastage investigations a dip mixture of sodium phenylphenate and hexamine in controlling green mould wastage in oranges has been successful. The new treatment is more promising than the borax, boric acid, and wax process previously tested. Paper wraps impregnated with diphenyl are as effective as the borax dip treat in reducing green mould wastage and more effe in reducing stem-end rots.

(ix) *Lemon Storage.*—Work over several season collaboration with Dr. T. B. Kiely (New South W Department of Agriculture) has shown that co main-crop lemons will keep in good conditio orchard shed storage for as long as six months less than 5 per cent. loss and with 99 per retention of fresh green colour in the buttons. successful treatment consists of dipping fruit, pi in June at the light green to silver stage of matu in a mixture of 2,4-D and the fungicide "Shi W.S.". Field trials have indicated that stem-end in storage can be controlled to some extent appropriate Bordeaux sprays.

(x) *Fungicides.*—More than 50 new chemical t ments for wastage control in oranges have screened. Nothing better than sodium phenylphe and diphenyl has so far been obtained.

(xi) *Spore-load Investigations.*—In collabora with Dr. T. B. Kiely, the influence of known level loading with spores of green mould on the subseq wastage in oranges has been investigated furt Methods have been developed for loading to stan spore loads and for estimating the actual surface s load both in those artificially loaded and those carr the natural spore load. This work is being use determine the effectiveness of various factors in bating mould wastage.

(xii) *Characteristics of a Good Keeping Orang* For many years it has been said that fruit wit smooth skin is less susceptible to mould wastage fruit with a rough skin but little critical work has done. Experiments on fruit with different degree smoothness of the rind treated with standard s loads showed that smooth-skinned Navels kept nificantly better than rough-skinned Navels but significant differences were found with Valencias.

(xiii) *Orchard Varieties and Storage Behaviou* In collaboration with the Irrigation Research Stat Griffith, work is being continued on the sto behaviour of fruits from different trees grown u the control conditions on Farm Block 466. Owin the shortage of fruit in the 1952 season the experin could not be repeated but the fruit is being stored a in the 1953 season.

(xiv) *Grapes—Substitute Packing Material.*- collaboration with the Division of Forest Produ experiments have been carried out to compare tralian sawdusts as packing material to replace standard granulated cork. The sawdusts used radiata pine, mountain ash, karri, and jarrah. Res indicated that sawdust, which is much cheaper t cork, may be satisfactory for grapes of the Oha variety.

(xv) *Control of Fruit Fly.*—Investigations of effects of the vapour heat-treatment and of fumiga with ethylene dibromide on the behaviour of com varieties of fruit are almost completed. The li of tolerance of the different varieties have been defi Experiments have been carried out in collabora with the New South Wales Department of Agricul to determine the effects of the treatments on the ins in fruit.

9. CANNING AND FRUIT PRODUCTS.

(Division of Food Preservation and Transport.)

(a) *Vegetable Canning.*—One further season's w on peas in Tasmania and New South Wales confirmed the usefulness of the maturom designed by this Organization for following maturation of pea crops and for providing informat ch permits accurate prediction of the optimal vest date two or three days in advance. Prior wledge of this date enables the canner to plan erly harvesting and to maintain uniform high lity in the canned pea pack. This procedure has n termed the short-term prediction of maturity in crops. Long-term prediction, on the other hand, uires an accurate assessment of the number of days m sowing to maturity. Statistical analysis of data 180 pea crops, grown in eight districts in Tasmania, wed that the relations between sowing date and days- naturity could be expressed as a series of straight es, which fall into early and late season groups. thin each group there was a common rate of matura- n of the crops. Long-term prediction of pea crop turity thus becomes a practical possibility, and the nning of canners' planting programmes can be atly simplified.

Attempts were made to extend these techniques of turity assessment to crops of green beans for can- g. It appears, however, that the maturometer re- res modification for use with green beans. The vent of mechanical bean-pickers makes it necessary to ard green beans as a one-pick crop. Investigations two crops of Landreth Stringless beans indicated t the yield of canning quality beans from a single k was about 10 per cent. less than the potential ld of the crop by successive pickings. Practically same yields were obtained whether the crop was ked at three, four, five, or six day intervals.

Tomato breeding trials were continued with the object developing a tomato with improved canning charac- istics. Canning tests and chemical analyses were de on twelve standard varieties, fourteen selections m the 1952 trials, and first and second generation brids from fourteen crosses. The hybrid tomatoes wed increased yields without loss of quality. A mber of field factors, as yet undefined, influence the ality and composition of tomatoes to a greater extent n variety.

(b) *Fruit Canning.*—The effect of maturity at pick- ; on the quality of apricots for canning was investi- ed, using the Trevatt and Moorpark varieties. Moor- k apricots showed best quality in the can when ked immature and ripened artificially. The Trevatt ricots, however, then picked immature, ripened to isfactory colour and texture but were excessively d in flavour. In a storage and ripening trial, evatt apricots were cool-stored for four weeks and ened to satisfactory canning quality.

The effect of maturity at picking on quality was also amined for the J. H. Hale variety of freestone peach. ain it was found that peaches picked immature and ened artificially gave a better canned product than e-ripened fruit. The freestone variety, Rio Oso m, was tested and found to be a suitable canning riety but not as good as J. H. Hale.

Investigations directed towards improvement of the ality of Tasmanian canned solid-pack apple were ntinued. Treatment with calcium salts gives a firmer oduct with better colour, and could be usefully applied over-mature fruit and some early, soft varieties. e addition of some water to the pack is desirable for hnological and economic reasons and it was found at 8-12 oz. could be added to a No. 10 (6-lb.) can thout affecting the quality.

The quality of canned berry fruits is also capable considerable improvement and investigations were nmenced on the specific problems of collapse and integration, and low drained weights. Samples of smanian raspberries, loganberries, gooseberries, and ckcurrants, covering a range of varieties and turities, were collected and analysed to provide data chemical composition, which it is hoped will provide basis for standard specifications for berry pulps. Berry fruits frozen in 4-gallon cans provided raw materials for jam manufacture much superior in quality to heat-processed pulps.

(c) *Fruit Juices.*—The marked influence of rootstocks on the quality of canned orange juice was confirmed in the 1952-53 season. *Poncirus trifoliata* when used as a rootstock for Washington Navel or Valencia oranges gives fruit of superior quality, and canned juice from this fruit is free from bitterness at an early stage of maturity. Rough Lemon rootstock with the same scions gives fruit of poor quality and canned juice that is bitter at all stages of maturity. A number of other rootstocks examined showed effects on fruit and juice quality intermediate between these extremes.

The chemistry of limonin, the main bitter principle of oranges, was further studied but it is not yet possible to define the structure of the molecule. Some exploratory studies on the biogenetic relations of limonin and associated bitter principles indicated that they occur in detectable amounts only in fruit of the orange tree, where they are concentrated in the seeds and the albedo, and that they disappear from all parts of the fruit as it matures.

(d) *Container Investigations.*—A need exists for a reliable test procedure for acid-resisting internal lacquers for cans. An acidified aqueous extract of beetroot tissue, containing the anthocyanin pigment betanin, showed promise as a test medium. Corrosion reactions in tinplate containers cause bleaching of the pigment and the extent of bleaching can be followed quantitatively.

The problem of sulphide staining in cans of food high in protein has prompted investigations on the liberation of labile sulphur from animal tissues during heat processing. A polarographic procedure is being used to determine sulphydryl groups and the rate of their disappearance on heating.

During the year sixteen commercial acid-resisting lacquers and twelve sulphur-resisting lacquers were examined for suitability as internal lacquers for food cans. In addition, a number of lacquer treatments, intended for glass container closures, were tested on electrolytic and hot-dipped tinplates.

(e) *Equipment.*—An experimental pressure spin-cooker has been constructed for processing canned foods in steam under pressure, the can being rotated axially during processing. The forced convection induced by this rotation increases the rate of heating of the product so that the total cooking time is greatly reduced and the quality of the product is enhanced. The usefulness of the spin-cooking procedure has been demonstrated for acid foods, and it is now hoped, by means of the pressure unit, to extend the principle to the processing of low-acid foods such as vegetables.

10. DEHYDRATED FOODS.

(Division of Food Preservation and Transport.)

(a) *Vegetables.*—Following the preliminary work of last year which confirmed the beneficial effect of starch coating on the storage life of dehydrated carrot, potato starch was fractionated and the resulting amylose and amylopectin fractions applied as processing treatments to carrots. A whole-starch treatment and untreated material were also included. This material was stored to study the rates of deterioration.

The rate of deterioration of dehydrated vegetables increases with increasing moisture content. Since air-drying to low levels of moisture content is uneconomic, other means of reducing moisture are sought. One of these is the use of "in-package" desiccants. The drying agent, in its own package which allows transfer of water vapour, is enclosed in the container holding the dried vegetable. The prerequisites of such a desiccant include (1) high water adsorption at low relative humidities, (2) non-toxicity, (3) lack of flavour and odour, and (4) cheapness. Some bentonite clays possess these attributes, and samples of Australian clays have been obtained to compare with types in use in the United States of America.

Preliminary trials have resulted in satisfactory drying of sweet corn, sweet peppers, and green beans (stringless varieties).

(*b*) *Fruit.*—At the request of the Dried Fruits Processing Committee, samples of dehydrated halved and sliced freestone peaches were prepared for distribution to bodies interested in the production of dehydrated tree fruits.

Equipment necessary for the study of uptake of sulphur dioxide gas by fruit before drying has been installed. That dealing with air speed and temperature has been tested and found satisfactory. The thermal conductivity equipment for the control of concentration of sulphur dioxide is not yet satisfactory and is being adjusted.

Concentration of sulphur dioxide gas in a small sulphur-burning box has been determined. A maximum figure of 4 per cent. was obtained, while, on many occasions, it was only 1 per cent.

(*c*) *Dehydrated Sugared Fruit.*—The chief study on this product was the storage characteristics of material prepared from syrups which had been used many times.

A trade report on the storage of sugared fruit was prepared at the request of the Dried Fruits Processing Committee.

(*d*) *Meat Dehydration.*—(i) *Compression of Dehydrated Mutton Mince.*—The compression of dried mince results in an appreciable saving in packing space and tinplate, and also it prolongs considerably the shelf life. It is accompanied, however, by some damage to the texture, the extent of which is governed by the compression technique. The investigations were extended to include the examination of a new technique, the results of which were satisfactory.

(ii) *Effects of Different Parts of the Carcass on Quality.*—Only certain parts of a mutton carcass are suitable for slicing and the remainder would be dried as mince. Consequently it was necessary to investigate the effects of different parts of the carcass on initial quality and storage life of the dried meat.

(iii) *Gas Packing.*—It had been demonstrated earlier that the packaging of dried meat in an inert atmosphere extends considerably the storage life. However, in commercial practice it would be difficult and costly to produce packs virtually free of oxygen. Experiments were carried out to obtain a measure of the effects of different levels of oxygen in nitrogen packs and also of the effects of different total amounts of gas in the packs.

(iv) *Addition of Flavouring Materials.*—Because dried mutton is rather bland in flavour, it was considered that the addition, during processing, of small amounts of flavouring materials would enhance the flavour and help to mask stale flavours produced during storage, without limiting its usage. A consumer preference panel is being used to evaluate the effects of a number of additives.

(v) *Storage of Dried Mince and Dried Slices.*—A fairly comprehensive storage programme has been continued throughout the year. The variables include time of storage, temperature of storage, and type of pack. Deterioration increases with increasing time of storage, increasing temperature of storage and increasing amounts of oxygen in the cans.

11. FROZEN FRUITS AND VEGETABLES.

(Division of Food Preservation and Transport.)

Work on the freezing of fruit and vegetables is co
ducted co-operatively with the New South Wale
Department of Agriculture. The programme of tes
ing varieties, evaluating methods of preparation, an
investigating such raw material factors as maturity an
handling practice in relation to the quality of the froze
product was continued.

(*a*) *Fruits.*—The testing of varieties of freeston
peaches for freezing which has extended over severa
seasons was continued. Sufficient data have now bee
collected to give a fairly reliable estimate of the freezin
characteristics of several local varieties. Similar wor
is in progress on apricots, cherries, plums, pineapple
mangoes, and berry fruits. Experiments on froze
cherries had previously provided information on th
behaviour of varieties prepared in different ways an
therefore no new work on cherries was undertaken las
season.

Chemical work on the browning of peaches durin
freezing is still in progress. Special attention has bee
given to the effect of added ascorbic acid, and of th
tannin and polyphenolase content of the peaches. Pre
liminary work on pineapples was commenced with th
object of studying raw material factors associated wit
the development of off-flavours in the frozen produc
A detailed investigation of the use of sulphur dioxid
in the freezing of Moorpark apricots was begun.

(*b*) *Vegetables.*—More attention has again bee
given to the freezing of peas than to other vegetable
The application of methods of maturity predictio
developed for canning peas has been successfull
extended to peas for freezing. Further data hav
been collected on the determination of th
maturity range associated with the highest accep
tability in frozen peas. Investigations on th
effect of handling and delay before processin
on the quality of frozen peas have been extende
to factory conditions. This project has been in pr
gress for several seasons and the results so far obtaine
have given a clearer picture of the deterioration occu
ring in raw peas caused by delays at different stag
of preparation. The use of precooling as a means
arresting deterioration has been investigated by obser
ing changes in palatability and by chemical analysis
the frozen peas.

(*c*) *Other Investigations.*—The installation of
experimental air-blast freezer has been completed a
equipment for controlling air flow and temperatu
measurement has been fitted. This unit will be used f
studies of freezing rates in relation to factors such
package size, air speed, and temperature. Sever
new packaging materials were tested for moistu
vapour permeability and suitability for frozen fo
packaging.

12. DRIED VINE FRUIT.

(Commonwealth Research Station, Merbein.)

Further laboratory trials have been made of t
removal of the "bloom" from the surface of grap
by immersion in warm ethylene dichloride. These ha
now been extended to include the currant and gordo
addition to the sultana. The extracts, after remov
of solvent, have provided the starting points f
chemical and physical examination of materials know
to be of complex composition.

As a preliminary to studies on the influence of vario
internal factors on the drying of grapes, expe
mental work has been carried out to establish a sampli
technique for grapes. Variations in sugar conte
from berry to berry on individual bunches have be
included in this study.

s part of an investigation on permeabilities of pes to water, both as liquid and vapour, rates of er loss and uptake through the cuticles of untreated rants, sultanas, and gordos have been determined.

An assembly of appropriate anti-oxidants and an estigation of analytical techniques for detection of cidity in edible oils have been made in connexion h the search for a suitable substitute for paraffin oil d in the final stages of packing-house processing of ed vine fruits. From time to time, prohibitions or trictions of the use of paraffin oil have been promul- ed by certain countries importing dried fruits. For s reason, work on substitute oils, begun some years o, will be continued as opportunity arises. Studies re also extended to ethyl formate which is an additive the final treatment in the packaging of dried vine its.

Trials continued with various dipping oils for pro- ssing of sultanas before drying have again demon- rated the effectiveness of the modern oils in the cold p for sultanas.

Among the hot dips for sultanas, the sulphite dip veloped by the Station was applied by a number of owers at Woorinen last season with very satisfactory sults. It has been found that increase in dipping time om 1 to 16 seconds in sulphite dip produced pro- essive increases in drying rate and lighter coloured uit. Further trials of rack dehydration have been nducted at Woorinen with particular reference to ltanas dipped in hot sulphite dip. Experience in a ial of dehydration of a full rack of green fruit with e equipment available indicated that greater capacity ay be required in the heating unit and that modifica- ns may be necessary in the duct work used to conduct ated air into the rack space in order to attain more iform distribution of heated air along the rack space.

13. Wine.

(Oenological Investigations, Waite Agricultural Research Institute.)

The investigations directed by the Committee on enological Research, which comprises representatives the Organization, the Federal Viticultural Council, e Australian Wine Board, and the University of delaide, have been continued at the Waite Agricul- ral Research Institute.

(*a*) *Sherry Investigations.*—The results of the inves- gations have been published by the Australian Wine oard in the form of a monograph; work on this bject has been discontinued for the present.

(*b*) *Wine Yeasts.*—The results of the laboratory sting of wine yeasts in the Waite Institute culture llection have been collated and prepared for publica- on. Further investigations have been conducted on e development of improved strains of yeasts by habi- ation procedures. Results to hand indicate that the ility of some strains of yeasts to ferment at high mperatures has been increased by habituation, but neral conclusions would be premature at this stage. n important aspect of the investigations is the study of e influence of conditions of culture and storage on the ability of the habituated strains of yeasts, and work s been started along these lines.

(*c*) *Bacterial Decomposition of Organic Acids in ry Wines.*—The decomposition of malic acid by cteria is among the more important changes occur- ng during the maturation of dry wines in Europe. nce this reduces the sourness of wines, it is often sirable but may be undesirable in some wines. The composition of tartaric acid, on the other hand, is ually associated with spoilage. A programme of investigations has been commenced with the object of determining the occurrence of these changes in Australian dry wines, their influence on the wine quality, and the methods by which they can be controlled.

14. Dairy Products.

(Dairy Research Section.)

(*a*) *The Utilization of Skim-milk Solids.*—One of the main justifications for dairy-farming as a method of land use, the outstanding ability of the dairy cow to change pasture into protein, calcium, and riboflavin in the form of high quality human food, is only valid if the non-fat milk solids do in fact find their way to human consumption. In seeking improvement in the utilization of skim-milk solids as one of its major objectives, the Dairy Research Section has given first attention to the development of a form of non-fat milk solids suitable for addition to bread. Details of the experimental work and the method of manufacturing the modified skim-milk powder have been published. The product has proved very satisfactory, and with it bread of high quality contining up to 12 per cent. of milk powder has been produced. Commercial production in Australia is now of the order of 500 tons per annum. Technical advice on manufacture has been given to several dairy factories.

The utilization of buttermilk for the same purpose was investigated. The baking quality of dried buttermilk was found to respond to the addition of bromate, glyceryl monostearate, and stearin in the same way as skim milk, and the optimum levels for these additions were found to be of the same order. Commercial buttermilk may sometimes be too alkaline, in which case the addition of acid is desirable.

Storage tests were undertaken to see whether milk powder could possibly be added to flour at the flour mill. After three months there was no indication of deterioration in flavour or performance.

Work was continued on egg substitute—a product made from skim milk with treatments differing according to the particular property of egg to be replaced. The substitute for egg-white in meringues and similar confectionery, reported last year, is undergoing commercial development, and help has been given in its large-scale production. A substitute for whole-egg in sponge cakes has been developed to the point where under laboratory conditions 80 per cent. of the eggs in the standard recipe may be replaced. Further work will be necessary. This work is part of a wider project for the development of new food forms from milk, and greater understanding of the physical and chemical changes involved must lead to more rapid progress.

Technical assistance has been given in the commercial production in Australia of yoghurt.

(*b*) *Oxidized Flavour in Milk.*—Previous work had shown that "oxidized flavour", a prominent defect in bottled milk in Australian cities, contained two components, one derived from oxidation of the butterfat, and one from the oxidation of skim-milk constituents. The chemical nature of the latter component, which may be isolated by steam distillation, is being investigated. From the 2,000 gallons or so of skim milk which has been distilled there has been obtained about 0.2 g. of a mixture of carbonyl compounds. These have been studied by preparation of the 2,4-dinitrophenylhydrazones and by chromatographic and other means, and appear to differ in important respects from carbonyl compounds isolated from oxidized butterfat.

(*c*) *Susceptibility of Butterfat to Oxidation.*—Cold storage of butter has become increasingly important in Australia in recent years. The problem of maintaining quality and bringing the butter to the consumer throughout the year at the highest possible quality level is a complex one, but the checking of oxidative deterioration is one of its major elements.

Studies on variation in the inherent susceptibility to oxidation of butterfats produced in the different dairying districts at various times of the year, and of the correlation of this with their content of certain unsaturated fatty acids and tocopherol, have been continued.

The extent to which samples of butter from the various dairying districts could be relied upon as sources of butterfat for such studies has been given attention. Fats churned from sweet cream appear to be more susceptible to oxidation than those churned from ripened cream neutralized to the same pH.

(*d*) *Weed Taint in Butter.*—Work on the physiological mechanism by which *Lepidium* spp. (peppercress) give rise to a high content of indole and skatole in milk and cream has stopped. It was possible to show that the effect of ingestion of *Lepidium* by the ruminant is to interfere with the normal detoxication of indole and skatole, thus giving rise to high levels of these compounds in the blood stream.

(*e*) *Structure of Dairy Products.*—Agitation of milk takes place by accident or design in many manufacturing processes. The behaviour of milk fat on the surfaces created during agitation frequently affects the efficiency of processes and the quality of the resultant product. By means of an overflow device the behaviour of fat globules on milk surfaces has been studied. Fresh milk surfaces free of fat show a rapid influx of fat globules when the surface is disturbed. The rising of air bubbles to the surface induces a similar effect, together with clumping of the globules and the formation of small patches of free fat. Such patches of fat may on disruption of the surfaces give rise to fat particles so small that they would not be recovered in the separation of milk or the churning of cream. A quantitative method for the study of fat globule behaviour on such surfaces has been developed and used.

The secondary structure of butter—the presence of cracks or lines of weakness—has been studied by the use of porous plates to absorb the liquid fat which normally acts as cementing material. Phase-contrast microscopy has been applied to this problem. The particles are on the very limits of visibility, but the method may prove useful for some purposes.

(*f*) *Cheese Starter Studies.*—A stock of efficient single-strain starter cultures has been established, together with a large number of bacteriophage races to permit typing of new strains. A visit to New Zealand permitted full benefit to be derived from the original work in this field which has taken place there.

The cultures originally brought from England had been selected because they were not affected by the phenomenon of "winter slowness" which occurs in the milk there. A similar and probably identical phenomenon has been apparent in many Australian dairying districts this season. The series of non-inhibited starters has been extended by the isolation of two further strains of suitable bacteriophage relationship. The cultures, which are distributed to cheese factories by State Departments of Agriculture, are being increasingly used in the industry, giving more rapid manufacture and assisting to lower costs and improve quality.

Ultraviolet light was found to be effective in the destruction of air-borne bacteriophage. *Streptococcus diacetilactis* was found to be a common constituent of commercial starters in Australia; its effect on cheese quality was studied. The behaviour of individual strains in blended and multiple cultures, and phage-carrying phenomena, have also been investigated.

(*g*) *Sweetened Condensed Milk.*—Approximately the same correlation was found between the refractive index of sweetened condensed milk and its total solids content
as between specific gravity and total solids. Neith
determination alone would give a better accuracy
controlling the condensing process than ± 1 per ce
total solids.

Colour, viscosity, and pH measurements were ma
on samples of sweetened condensed milk bought
officers of the Department of Commerce and Agric
ture as representative of the milk available in t
world's main markets. Assistance was given to t
Department and to the industry in the study of t
causes of defects in samples of Australian sweeten
condensed milk.

(*h*) *Other Investigations.*—Minor studies have
cluded the effect of "Neoprene" and of a polyvir
chloride lining, possibly useful materials in the co
struction of dairy processing equipment, on mi
flavour, and their resistance to cleansing treatment
the relation of type of milk powder to the quality
reconstituted milk; the sterilization of chocolate mil
and improvements to the volumetric methods of f
estimation in milk and cream.

XIV. FOREST PRODUCTS.

1. GENERAL.

Australia possesses a great variety of timbers, ma
of which are of considerable commercial value. Func
mental data regarding properties, potentialities, a
correct methods of treatment are essential to the fu
and proper exploitation of our timber resources.

The work of the Organization in this field is carri
out by its Division of Forest Products which has
laboratories in Melbourne and the work of this Div
sion for the current year is reported in this Chapte
Some work on timber pests is undertaken by the Div
sion of Entomology (*see* Chapter IX.).

Division of Forest Products.—The aim of this Div
sion is to give direct assistance to all concerned in t
utilization of forest resources. Its work is directed
the more effective use of these resources by reducin
waste in forest, mill, and factory; by reducing loss
from decay and insect attack; and by improving t
quality of timber produced in the growing forest by
study of the relationship between silvicultural trea
ment and timber properties.

Although the timber and allied industries ha
operated at a reduced level, this has not resulted in a
reduction of requests for assistance from the Divisio
The industry has never been so conscious of the ne
for improving standards, efficiency, and techniques a
has drawn very freely on the Division for advice.
the whole field of the Division's work the number
inquiries has risen to 8,000 per year and the number
visitors to the Division has increased to 1,600.

A ten-day course in forest products was given to t
fourth-year students of the Australian Forestry Scho
Canberra, and the courses for forestry and archite
tural students of Melbourne University and for t
Supply Management Class and the Building Scien
Class at the Melbourne Technical College were co
tinued. The special course of a week for third-ye
students of the Victorian Forestry School, Creswic
was repeated again this year. A number of lectur
and talks were given to outside establishments interest
in the work of the Division.

The Forest Products Research Conference held
November, 1952, was well attended with delegates fro
State Forest Services, the Commonwealth Forestry a
Timber Bureau, other Commonwealth organization
and the New Guinea Department of Forests. The Pu
and Paper Co-operative Research Conference was he
at the beginning of the year and was attended
technical officers from the contributing companies. Th

ivision also took part in the Seventh Australian Pulp nd Paper Industry Technical Association Conference nd in the Eastern States Timber Industry Stabiliza- on Conference in Hobart.

Dr. W. E. Cohen, Officer-in-charge of the Wood hemistry Section, was seconded for three months to .A.O. Head-quarters in Rome; Mr. R. F. Turnbull, fficer-in-charge of the Utilization Section, attended ne second session of the F.A.O. Asia-Pacific Forestry nd Forest Products Commission in Singapore; and ne Chief of the Division attended the Sixth British ommonwealth Forestry Conference held during the ear in Canada.

The help and co-operation of the paper companies, ne Commonwealth Forestry and Timber Bureau, the tate Forest Services, the New Guinea Department of orests, and all branches of the timber and allied indus- ies are gratefully acknowledged.

2. WOOD AND FIBRE STRUCTURE.

(Division of Forest Products.)

(*a*) *Anatomical Investigations.*—(i) *Wood.*—The udy of the anatomy of the woods of the Myrtaceae ccurring in the south-west Pacific area has been com- leted and accepted for publication in the *Australian ournal of Botany.* Woods of the Burseraceae and unoniaceae from the same area are being examined. n view of the recent description of sixteen new species f *Nothofagus* from the New Guinea area, an examina- on of the wood anatomy of certain of these species as been made in comparison with that of the species ccurring in Australia, New Zealand, and South merica. Work has continued on various Australian, ew Guinea, North Borneo, and Solomon Island mbers which have not been previously examined natomically.

(ii) *Bark.*—During the year a considerable number f specimens from various species of the genus *ucalyptus* has been collected and, to date, 765 samples rom 220 species have been sectioned and examined. rom these investigations it is now possible to make a rouping of species on bark characteristics and to com- are such a grouping with that published by Blakely n anther characteristics. In some species of eucalypts onsiderable variation in bark anatomy has been bserved. In such cases many samples have been ollected over a wide range of trees from different ocalities in order to assess the variability both within nd between trees. The evaluation of hybridization etween certain eucalypt species has been carried out n collaboration with taxonomists interested in this eld. It is possible that the range of variation in some pecies mentioned above is due in some degree to ybridization.

(*b*) *Identifications and Identification Methods.*— ver 800 timbers have been identified, many of these oming from trade sources, Government Departments nd individuals. On the other hand, quite a large roportion were specimens obtained through field ollections in New Guinea, the Solomon Islands and orth Queensland. In such cases identifications based n wood anatomy were carried out to assist final otanical determinations of the material collected. dentification keys have now been prepared for the arious timber species occurring in mangrove associa- ons and full anatomical details of each timber nvestigated have been recorded. Cards covering 25 orth Queensland timbers not originally included in ne card-sorting key for commercial Australian timbers ave now been prepared and copies sent to Forestry chools and State Forest Services. Thirty-six addi- onal sets of the card-sorting keys based on microscopic eatures have been distributed. Further work has been completed on North Borneo timbers and the results transferred to cards for inclusion in the card-sorting key developed for the timbers of this region.

(*c*) *Cell Wall and Fibre Studies.*—(i) *Hydrolysis Patterns.* — The patterns developed when acid hydrolysed fibres are oven-dried or swollen in alkali are well known but not satisfactorily explained. Possible factors causing the development of such patterns have therefore been investigated. On the basis of techniques involving the electron microscope and polarization optics it has been concluded that the patterns arise from preferential hydrolysis in the region of the cell wall deformations and, in part, from the operation of stresses during drying. They are in no way associated with any intrinsic structural feature of the cell wall as suggested by other workers.

(ii) *Cell Wall Organization.*—Examination of cambial cell walls by means of the electron microscope has revealed the presence of a structure approximating the so-called "fibroid" texture with both transversely and longitudinally oriented micellar strands. The relative orientation of the micellar helices in the different layers of the secondary wall has now been definitely established. In earlier work the angle of micellar orientation in the middle layer of the secondary wall—this angle is an important factor in determining wood properties—was shown to depend on cell dimensions. However, specimens of *Pinus taeda* and *P. caribaea* grown in Queensland and recently examined show this dependence to a markedly less degree and the possibility that some other factor influences micellar orientation in these species must be considered.

(iii) *Cell Length.*—The variation in tracheid length throughout a 36-year-old tree of *Pinus radiata* has been studied. At each of the fifteen levels investigated the tracheid length increased rapidly over the first ten growth rings from the centre outwards, after which there were only small fluctuations. The longest tracheids were found in the outer rings between 20 and 30 feet above ground level in this tree which was 82 feet high. The work designed to produce trees of *P. radiata* of high average tracheid length has been continued in co-operation with the Forestry and Timber Bureau, Canberra.

(iv) *Fibres of New Guinea Timbers.*—Considerable information has been obtained on the fibre dimensions and the ratio of wall thickness to lumen diameter in various specimens of mangrove species and in specimens of hoop and klinki pines. This information has been required in connexion with the pulping studies of New Guinea timbers.

(v) *Examination of Fibres from Various Eucalypts.*—To supply information on fibre dimensions of various species of the genus *Eucalyptus* being used for pulping, determinations have been made of average fibre length, average fibre diameter, and the ratio of cell wall thickness to cell diameter in representative samples of fifteen species of pale-coloured eucalypts.

(*d*) *Tension Wood.*—The fundamental structural characteristics of tension wood have been investigated by microchemical and X-ray diffraction methods in an extension of earlier work on this type of reaction wood. As a result several leads have been obtained relative to the causes of the abnormal behaviour of this tissue, e.g. development of woolliness in sawing. A developmental study has revealed a series of morphological features associated with its formation, and some of these appear to correspond with features observed in eucalypt woods of good quality for the production of groundwood. In this connexion the point of fundamental importance appears to be the degree of lignification in the tissues and this is intimately correlated with geotropic response. Investigations have therefore begun on the distribution of lignin in the cell wall using techniques of ultraviolet absorption and electron microscopy. X-ray diffraction studies of types of tension wood containing the distinct inner gelatinous layer reveal an exceptionally high micellar orientation and, in fact, the diagrams obtained closely resemble those from ramie. The X-ray diagram of typical tension wood can thus be regarded as one in which a diagram of highly oriented cellulose is superimposed on the more diffuse diagram of normal wood.

(*e*) *Growth Studies*.—(i) Pinus taeda *and* P. caribaea.—The growth pattern in the wood laid down over a twelve-month period has been determined for the above two species using samples taken from three positions in 36 trees of each. Results obtained for both species show that there was no actual cessation of radial growth throughout the year although it was least pronounced in September. Radial growth was considerable between September and November, when typical early wood was being formed; this corresponds to the period of most marked height growth. During December to March early wood was still being laid down, but in the period March to August, when there was no height growth, most of the growth ring was formed. Between June and August late wood developed. From these preliminary results it would appear that most radial growth takes place in the period of least height growth.

(ii) *Radial Fissures in the Early Wood of Conifers*.—In certain conifers excess of water loss over uptake during late wood formation may cause partial collapse and radial cleavages in the early wood. Living ray cells are exposed in the cavity formed by the cleavage and are stimulated to active growth. Different species show different responses to this powerful growth stimulus. Thus the cavities fill with cellular tissue in radiata pine, with resin in Douglas fir, and remain empty in spruce. Reasons for this varied response have been found in the anatomy of the ray cells for the various species.

(iii) *Spiral Grain*.—Studies on the occurrence and distribution of spiral grain in the stems of various conifers have commenced and several possible techniques for its detection in living stems tested.

(*f*) *Bark and Wood Extractives*.—Rutin and ellagic acid have been isolated from extracts from some of the eucalypt species examined previously, thus confirming the evidence obtained by paper partition chromatography. An adsorption chromatographic method of separation is now being perfected; this technique will allow separation of the various components of extracts to be made on a larger scale and will greatly facilitate their examination. Using extraction and crystallization techniques, eudesmin, aromadendrin, and a third compound have been isolated from the kino of grey box (*Eucalyptus hemiphloia*). The unknown substance is being examined.

During the general examination of the cellular kino of jarrah to find means of converting it into a suitable tannin extract, several samples from different trees were found to have up to 20 per cent. material soluble in hot water. This is much higher than the average (about 5 per cent.). Methods used to examine leucoanthocyanins in *Butea frondosa* kino have been explored to assist the investigation of such substances in jarrah. However, repeated trials with these methods have failed to produce the results claimed.

Several mangrove barks from New Guinea and eucalypt barks from Western Australian species have been analysed for tannin content. The extract from the bark of one eucalypt species not previously investigated has been tested by a local tannery. It was reported that, although this extract was unsuitable alone, it could be blended with other extracts to produce a satisfactory leather.

3. Wood Chemistry.

(Division of Forest Products.)

(*a*) *Lignin and Related Compounds*.—The searc
for more suitable solvent systems for the chromat
graphy of lignin has been continued. Confirmation
the existence of two lignin fractions has been obtain
by the use of methanol:*iso*propyl ether:wat
(40:80:20) which gave fractions at R 0.05 and 0.9
and acetone:methyl ethyl ketone:water (25:75:10
which gave lignin fractions at R_F 0.24 and 0.28. T
identification of two definite lignin fractions at fini
R_F values is a definite step in the elucidation of t
chemistry of methanol lignin from *Eucalyptus regnan*
Resolution of the lignin by counter-current distributi
is rendered difficult by the presence of numero
impurities, and a study of the removal of t
impurities by solvents has therefore been made wi
the object of attaining a partial purification witho
denaturing the lignins. Prolonged cold water extra
tion appears to be the most successful yet tried and
being investigated further.

(*b*) *Wood Carbohydrates*.—A bulk sample of wate
soluble carbohydrate material extracted from methan
cooked *E. regnans* wood has been separated into
fraction insoluble in 60 per cent. ethanol and a fracti
soluble in 60 per cent. ethanol but insoluble in 90 p
cent. Conditions for the hydrolysis of the latt
fraction with N sulphuric acid have been establish
by the use of optical rotation to follow the course
the reaction. Chromatographic analysis of t
hydrolysate carried out by separation in a cellulo
column revealed the presence of xylose, galactose a
uronic acid.

The barium aldobiuronate prepared from *E. regna*
wood gave with methanolic hydrogen chloride a pa
yellowish syrup which on treatment with methanol
ammonia yielded a crystalline mass. By suitab
fractional crystallization a product was obtained whic
from its constants, was identified as the ami
of methyl-4-*O*-methyl-α-D-glucopyranosiduronic aci
The β-form was isolated from the mother liquo
Treatment of the remaining liquors with methanol
hydrogen chloride containing benzaldehyde gave t
dimethylacetal of dibenzylidene-D-xylose. Thus t
aldobiuronic acid of *E. regnans* is believed to consi
of D-xylopyranose units linked with 4-*O*-methyl-
glucopyranuronic acid units.

(*c*) *The Mechanism of Delignification*.—In inves
gations on the influence of chip shape on the course
delignification of *E. regnans* wood by sodium hydroxi
and sodium sulphide solutions, sawn "chips" cut wi
faces as near as possible in the longitudinal, tangenti
and radial planes were pulped. Results obtained we
compared with results of pulping matched materi
subdivided in different ways. Penetration of N
sodium hydroxide took place with almost equal ea
in the three directions, whereas with sodium s
phide the penetration in the longitudinal direction to
place somewhat more rapidly. No effect on the cour
of delignification was noted when 1-in. cubes of wo
were crushed under a load of 1,000 lb./ square inch
a tangential direction, nor was there any differen
between the strength properties of the pulps fro
crushed and uncrushed specimens. A method has be
established for the determination of the cupriethylen
diamine viscosity of pulps from the delignificati
studies.

(*d*) *Pulping of New Guinea Woods*.—The pulpi
properties of representative samples of virgin a
plantation grown hoop pine (*Araucaria cunninghami*
and klinki pine (*A. klinkii*) have been determine
Both species pulped readily by the sulphate proce
giving good yields of shive-free pulps. Only sma

ferences in chemical composition and pulping char-
eristics were noted between the individual trees of
h species and, in addition, the pulps from both
cies were very similar. The strength properties of
pulps from plantation grown trees were lower than
se from the older virgin trees. The difference was
st noticeable in the case of tear; a result which
s not unexpected because of the lower average fibre
gth from the younger trees. A slightly higher tear
tor was obtained with pulp from plantation grown
p pine, in comparison with pulp from plantation
wn klinki pine. This again was correlated with
slightly higher average fibre length of the former.
initial tearing resistance of pulps from both
cies was very high and the other strength properties
npared favorably with those of high-grade spruce
ft pulp. With a mixed furnish of 20 per cent.
nki pine pulp and 80 per cent. *E. regnans* kraft pulp
increase in strength properties of the test sheets was
per cent. in burst, 9.2 per cent. in breaking length,
19 per cent. in tear over those obtained for the
nans pulp alone.

e) Fibre Structure in Relation to Pulp Properties.
uccessive growth rings from a plantation grown
of *Pinus taeda* were subdivided into early and late
od and each part of each ring pulped separately by
sulphate process under comparable conditions. All
ps so obtained were bleached to remove remaining
nin and on analysis they were found to be similar
hemical composition except for small variations in
tosan content which followed the changes in pen-
n in the original wood. Pulps from the early wood
each growth ring had much higher bursting strength,
sile strength, folding endurance, and air resistance,
lower tearing resistance and bulk than the pulps
n the corresponding late wood. Pulp strength pro-
ties varied considerably from growth ring to growth
g for both early and late wood. There was a good
eral correlation between basic density of the wood
the properties of the test sheets, a high basic density
ing a high bulk and tear but low bursting and tensile
ngths, folding endurance, and air resistance. Struc-
al factors governing basic density, namely, cell
neter and cell wall thickness, appeared to have
reater influence on pulp properties than cell length
nicellar orientation.

f) Beater Studies.—Preliminary investigations
e been made on the operation of the recently installed
esford laboratory beater, before a detailed examina-
of its beating characteristics. The performance
he laboratory Lampen mill which has been used
general evaluation work for a number of years
wed no significant difference from that of a new
except in the case of freeness (C.s.f.) where the
oratory mill gave significantly lower results.

g) Rheological Studies on Paper.—A rheometer for
suring stress-strain-time relationships on paper
ps has been constructed. The instrument operates
neans of electronic servo-mechanisms and is able to
duce a continuous record of the interdependence of
two of the above rheological variables, or their
vatives, over the ranges likely to be encountered in
er investigations. The rheometer will also be used
studying the relation of physical properties to
structure of paper and problems arising during
nufacture. One of the principal problems involves
control and measurement of relative humidity, and
eriments have been carried out in an effort to obtain
stant relative humidity over a wide range.

h) Folding Endurance of Paper.—The folding en-
ance of paper is a property which shows high vari-
ity in readings obtained on similar sheets and, after
rumental modifications which improved the per-
nance of the M.I.T. fold tester very considerably,
it was concluded that the source of much of the residual variance must be in intrinsic factors within the paper. The effect of moisture content differences consequent upon small changes in relative humidity was pronounced but quite insufficient to account for the large variation in results. A linear relationship between basis weight and folding endurance was established, and small fortuitous variations in basis weight could not account for observed variability. Fibre length was found to exert a very critical effect upon folding endurance. Fractionation of eucalypt and pine pulps showed that the folding endurance passed through a minimum with increasing fibre length, indicating that two distinct mechanisms contribute to the fold endurance. The influence of the period of beating was also studied; folding endurance continues to increase long after the tensile strength reaches a constant value, presumably as a result of the increasing amount of fine material produced.

(*i*) *The Mechanism of Beating.*—An investigation has been commenced into the nature of the essential changes induced in cellulose fibres by beating. Examination of the filtered supernatants from beaten and unbeaten pulps showed an increase in optical density on beating, and attention has been directed initially to the significance of the colloidal material liberated. Unbeaten eucalypt and Ljusnan kraft pulps and similar pulps beaten to 18,000 rev. in the Lampen mill were fractionated by removal of the fine material, and the properties of the residual fractions and the whole pulps were compared. The results indicated the relative importance of the liberation of the fine material during beating as an important factor in the production of desirable papermaking properties, compared with the changes in the fibres in other ways which influence the properties of the sheet.

4. TIMBER PHYSICS.

(Division of Forest Products.)

(*a*) *Physical Properties of Wood and Related Materials.*—(i) *Shrinkage and Density Measurements.*—The British and American standard tests for determining shrinkage have been studied and modifications to the testing procedure recommended. Significant errors are introduced into the results by measuring the oven-dry specimens while still hot. Transverse and longitudinal shrinkages can be measured satisfactorily on a single 1 by 1 by 4 inch specimen with the length parallel to the grain.

Shrinkage and density tests have been completed on material of 30 species from the Pacific islands. Tests are in progress on 150 Australian species, including a large number from north Queensland not previously tested. Material is being tested from some 30 trees of plantation grown radiata pine between 20 and 40 years old. Shrinkage and density tests are being carried out on a number of trees of *Eucalyptus rossii*, *E. robertsoni*, and hybrids of these species. Large variations have been observed in the shrinkage and density of radiata pine bark with position in the tree, the density and radial shrinkage increasing considerably with increase in height.

An investigation to establish the most satisfactory method of determining shrinkage intersection points is in progress. They are being determined firstly from the shrinkage over different moisture content ranges, secondly on different sizes of specimens, and thirdly from the total volumetric shrinkage and basic density, on the assumption that all water sorbed at moisture contents below the intersection point produces an external swelling equal to its own volume.

The variation in the longitudinal shrinkage-moisture content relationship throughout a growth ring is being investigated.

The shrinkage-moisture content relationship has also been studied for specimens consisting entirely of a medullary ray, and material free from rays. It has been found that in contrast to other wood, the shrinkage of the rays parallel to the axis of the tree is considerable, but it is small in the radial direction of the tree.

(ii) *Wood-liquid Relations.*—Further tests have confirmed that the apparent density of wood substance increases with increase in external swelling owing to the displacement liquid. Within a single homologous series, a decrease in apparent density appears to accompany an increase in molecular weight, although no overall correlation between apparent density and molecular weight of the displacement liquid has been observed.

The study of the effect of temperature on the moisture content-relative humidity relationship has been continued. The apparatus used has been modified and the determination of moisture content is now being made using a McBain-Bakr quartz spiral balance.

A precision calorimeter has been constructed for use in measurements of the heat of wetting of wood by water over a range of temperatures.

(iii) *Creep.*—Tests on air-dry mountain ash beams under prolonged loading have shown that, at extreme fibre stresses from half to three times the normal design stress, the deflection continues to increase for at least two years reaching up to four times the initial value. Measurements of decrease in deflection after unloading indicate that the proportion of plastic flow to elastic after-effect is lower for dry beams than for green ones.

Creep in hoop pine in bending was compared with that in mountain ash but no significant difference was found even for two such structurally different timbers. Thus creep is apparently not markedly dependent on species.

Tensile creep tests show that although creep of wood in tension causes a smaller proportional increase in strain than in bending, it continues for at least 1½-2 years. In compression, it appears to be still smaller than in tension. At stresses below about 10 per cent. of the ultimate strength, no creep has been observed in compression specimens which have been under load for approximately a year. This is in contrast to tension and bending where creep was found to occur at these low stresses. After prolonged loading in shear for a few months at a stress equal to one-third of the ultimate strength, specimens showed an irrecoverable deformation which was small compared with the recoverable, but the irrecoverable portion increased with increasing temperature. The deformations, which were measured with electrical resistance strain gauges, reached about twice their initial values.

Relaxation tests were carried out on air-dry hoop pine beams which were kept at constant deflection. These showed that the forms of the creep and relaxation curves are of a reciprocal nature as for certain other materials.

(iv) *Thermal Properties.*—The galvanometer amplifier and automatic timing equipment of the apparatus for measuring thermal conductivity have been redesigned and rebuilt. The timing equipment now gives timing periods of 5, 10, 25 and 50 seconds, different reading intervals being desirable at different stages of the experiment.

The temperature control of the air-conditioned laboratory for this work has been improved by installing a resistance bridge temperature controller, and variations of only about ± 0.2° C. are now obtained.

(v) *Electrical Properties.*—Moisture meter correction figures have been determined for material from ten trees of jarrah and from eleven trees of South Australian-grown radiata pine.

A study has been made of the effect of depth of el trode penetration on the readings of a moisture me used for testing plywood glued with casein adhesiv The results indicate that errors are increased by t penetration of the gluelines by the electrodes and poi to the desirability of investigating surface electrod

The dielectric constant and power factor of wh cheesewood have been determined at frequencies up 70 Mc/s. The objective is the design of a moistu meter for impregnated timber.

(vi) *Testing of Building Boards.*—The capilla rise of water in two types of hardboard and one insul ing board has been studied and is not considered serio in practice. Total immersion tests have been carri out on 21 types of hardboard and ten types of insulati board which are available in Australia, the wat absorption and swelling in length and thickness bei determined. The dimensional stability of these bui ing boards is being studied over a large range of relati humidities for repeated cycles of conditioning. investigation of the effect of moisture content and te perature on the tensile strength and Young's modul of hardboard is in progress.

(*b*) *Battery Separators.*—Following examination billets from klinki pine top logs, it appears likely th with careful selection, a proportion of top logs could used for battery separators.

Comparative resistance tests on separators of P Orford cedar and on separators from a large consig ment of north Queensland kauri were carried out a firm of battery manufacturers to check on abnormally high resistances obtained. The cause of trouble was found, and satisfactory separators are n being produced from the kauri stocks held by manufacturer.

(*c*) *Strain Gauges.*—The test on a hydraulic cyl der belonging to the Preservation Section was succe fully carried out using nitrogen as the pressure medi and measuring strains with electrical resistance str gauges.

It has been possible to glue thin aluminium foil green timber and so form a moisture-proof barrier which to glue resistance strain gauges. It is hoped this way to be able to use these gauges on gre timber.

The use of resistance strain gauges for creep testi is being studied on a large scale to check stability o long periods.

5. TIMBER MECHANICS.

(Division of Forest Products.)

(*a*) *Studies of Properties and Testing Methods.* To obtain a practical yet accurate method for adjusti strength test values for differences in moisture conte investigations have been commenced to determine relation between the moisture intersection point obtai from strength studies and that determined from shri age studies. Data which have been accumulated ha indicated that previous estimates of the shrinka intersection point for jarrah were too high; so far satisfactory relationship with the strength intersecti point has been established.

The absence of a generally accepted empirical meth of adjusting impact test results for differences moisture content has led to investigations of the eff of moisture content on the toughness of bunya pine a mountain ash. In addition, a large amount of imp data from other species is being studied.

Following the development of a dropping ball te nique to indicate the impact hardness of wood, co parisons are being now made between ball drop a Janka hardness.

Experiments on trees of mountain ash, representative a wide range of size and age, have provided additional ormation on the variation of properties with height d radial position within the tree. By comparing dial position from the bark a more defined relation- p was obtained than when the pith was used as tum.

Comparison of the effect of loading impact and static nding specimens on the inner and outer tangential d radial faces was studied on silvertop ash, brown ingybark, and white stringybark. The results of ts on tangential and radial faces were significantly ferent, as is normal, but the effects of loading on ner and outer tangential faces were not significantly ferent both for green and for dry material. In nparisons of test measurements on small and stan- rd size specimens, the smaller specimen gave signi- antly higher values for modulus of rupture but lower lues for modulus of elasticity.

The effect of rate of loading in the testing of fibre- ards is of interest in the development of specifica- ns for standard methods of test for this material. nding tests have been conducted on both hardboard d insulating board at three loading rates, viz. 0.004, 04 and 0.4 in./min., and it is proposed to extend the vestigation with tests carried out at 0.0126 and 0.126 /min. Different spans and types of support are being ed in bending tests conducted to study the effects of rge deflections, friction at the supports, and size of pports on modulus of rupture.

(*b*) *Species Testing.*—The determination of the echanical properties of timber from the more import- t species continued steadily throughout the year. ost represented species was radiata pine from South ustralia, but others include messmate stringybark, own stringybark, white stringybark, red gum, red x, grey box, peppermints, yellow box, tallowwood, ackbutt, turpentine, brush box, jarrah and New uinea malas. A full range of tests was completed on proximately 100 logs of green material and 110 logs dry. In addition, tests were conducted on 90 miscel- neous species from Queensland, 32 logs representing calypt hybrids from the Australian Capital Terri- ry, three species of New Guinea timber, and one jian species.

In Victoria the systematic sampling within districts representative material of all important species is oving quite satisfactory from the viewpoints both of llection and of laboratory organization.

(*c*) *Silvicultural Tests.*—To compare the properties parent and progeny trees of slash and loblolly pines lected as a basis for the establishment of future plan- tions in Queensland, a considerable amount of work s been done using small compression specimens cut ong a radius from bark to pith. Investigations have en made of the correlations between density, percent- ge summerwood, and compression strength. The study s been extended to a large number of trees of radiata ne. These were drawn principally from South Aus- alia (50 trees), but other material has been obtained om Victoria and New Zealand. High correlations tween density and strength have been obtained. The rcentage of summerwood is being determined in all ees to enable correlation with the specific gravity of dividual growth rings, and rates of growth are being udied to determine effects of silvicultural treatment.

The relations between the mechanical and physical roperties of hybrid eucalypts are being studied with e aid of similar experiments and correlations.

(*d*) *Timber Construction.*—Long-term loading tests simple tension joints with single split ring connectors shear plates have been under observation for periods p to eight years. These and more recent tests to eck the significance of such effects as end distance nd splitting have reached a stage where analysis is stified.

In the investigation of the short-term loading capacity of columns a report has been prepared on the effects of variables on column strength and the most satisfactory formula for estimating maximum loads.

The testing of model columns 2 by 1½ inches in cross-section under constant long-time load was continued and extended to other species and another moisture condition. Altogether 106 columns have now been set up, 79 of mountain ash, sixteen of Douglas fir, and eleven of yellow stringybark. Most of the columns have been maintained green but nineteen have been allowed to dry out. There was some evidence that atmospheric temperature variations were producing significant effects, and columns are now being kept in controlled temperature rooms. To date, 27 of the 39 columns loaded to 70 per cent. of their estimated short-time capacity have failed, most within the first month and many within a few days. Of the twelve still standing (maximum period ten months) eight are long columns of green mountain ash. Nearly half of the columns under a 60 per cent. load and one-quarter of the columns under a 50 per cent. load have failed, the minimum failure periods being two and eleven months respectively. All except the heavily loaded columns were of green mountain ash.

Experiments on the effect of a concentrated load over a joist in a flooring system have indicated considerable distribution of load to adjacent joists. This information is of considerable importance in the design of sizes of members and is being reported.

A study of the effect in laminated beams of using external laminae of relatively strong species over a core of lighter and weaker material has been completed. Selected mountain ash was glued to a core of radiata pine from plantation thinnings. The strength and stiffness of model beams appear to increase parabolically wtih increasing thickness of outer laminations.

Although nailing provides an effective and economical method of fabricating a large range of timber structures, information on the design of nailed joints in Australian species is very limited. Experiments are being confined to behaviour in simple joints consisting of one or two nails. The splitting effect of nails driven near the end of pieces is being investigated and withdrawal resistance measured. Some tests have been completed and others are planned for standard smooth finish nails and a number of species including messmate stringybark and radiata pine.

(*e*) *Growth Stresses in Trees.*—In the conversion of timber from log form to veneer, growth stresses may cause splits which seriously limit its value. With some species this tendency to split is increased by heating or other pre-treatment. Experiments are being conducted to determine the significance of temperature in causing expansions or contractions in longitudinal, tangential, and radial directions and to determine the effect of heat in causing relaxation of growth stresses in the log. Loss of strength is also being measured.

Observations have been continued on seven young mountain ash trees of age approximately thirteen years and ranging in girth from 9½ to 22 inches. These were severely bent by abnormal snow loads approximately two years ago. Most trees showed very marked straightening in November-December, 1951, but little change has taken place since.

6. TIMBER PRESERVATION.

(Division of Forest Products.)

(*a*) *General.*—In addition to normal research activities, officers of the Section have been largely occupied by numerous requests for technical assistance, and with miscellaneous practical tests, demonstrations, and discussions relevant to the establishment of preservation plants in Australia.

(*b*) *Field Tests.*—Field and service testing of preservative-treated timber has continued to be an important practical project. During the year inspection was made of *Pinus radiata* test sleepers installed in track tests in six localities in South Australia. This test was commenced by the Division in 1936, in co-operation with the South Australian Railways and Woods and Forests Department. Results after almost seventeen years' service have now clearly demonstrated that *P. radiata* sleepers, pressure treated with a preservative oil, give very satisfactory service and may possibly outlast untreated jarrah sleepers which were installed in the same test as controls. The successful utilization of pine sleepers is now dependent mainly on availability.

(*c*) *Pressure Treatment of Rail Sleepers.*—During the year the new high-pressure pilot plant has been in almost continuous operation and has been mainly used for the experimental treatment of rail sleepers for co-operative tests. Approximately 1,700 sleepers have been treated, mainly during the current year, for Victorian, Tasmanian, Western Australian, and Commonwealth Railways. These sleepers have been treated at high pressures (1,000 lb./sq. in.) and absorptions have been generally satisfactory. In addition, a small number of New Guinea mangrove sleepers has been treated and installed in track tests to demonstrate the possibility of using the considerable potential supplies of this timber for rail sleepers. Unlike eucalypt heartwood, which can be penetrated with preservatives only at high pressures, the three species of mangrove tested were readily treated at low pressures.

(*d*) *Causes of Failure of Crossarms.*—The survey, in co-operation with the Postmaster-General's Department, to determine causes of failure of crossarms in service, has been completed for all States and the data obtained are being analysed and reported. In addition, an inspection of crossarms between Port Augusta and Kalgoorlie was made at the request of, and in company with, P.M.G. officers. Recommendations for modification of crossarm specifications and for practices to increase service life are being made.

(*e*) *Non-pressure Treatment of Round Timbers.*—Methods of treatment of poles and fence posts without application of pressure have been further investigated. A method of treatment by alternate hot and cold spraying with a preservative oil has been developed and demonstrated to pole-using authorities. This treatment has given satisfactory absorption of preservative in sapwood similar to that obtained by the conventional open tank process. It is considered to be applicable to the treatment of poles in small depots where large-scale plant would not be justified.

Particular attention is being given to development of simple methods for treating round fence posts. Field tests over many years have demonstrated that small round posts of any species can be treated to give a life equal or superior to split posts of the most durable timbers. The successful use of round posts by farmers is thus assured if the methods of treatment are sufficiently simplified.

(*f*) *Toxicity and Permanence of Water-borne Preservatives.*—The first series of tests to determine the resistance to leaching of nineteen water-borne preservatives has been completed. In these tests sapwood blocks of *Eucalyptus regnans*, impregnated with known amounts of preservative, were leached in distilled water at constant temperature in a shaking machine for a total period of 128 days. During the leach the water was completely changed twelve times and at each change the water was analysed to determine the progressive removal of preservative. At completion of the leach, blocks were analysed to check the residual quantities of preservative. Decay resistance tests on leached and unleached blocks are also in progress.

Results obtained have given a valuable picture of the relative permanence of different preservatives, and greatly extend the usefulness of field test results. While such laboratory tests do not replace field testing, they are most useful in predicting the performance of preservatives under conditions which do not simulate normal outdoor service.

Further work is now in progress to determine the effect of timber species and of pH of the leach water on the permanence of water-borne preservatives.

(*g*) *Timber Mycology.*—Tests on the comparative resistance to decay of various Australian timbers are now in progress. This is a long-term project in which much preliminary work has been necessary to develop and standardize testing techniques and to collect authentic and fully representative specimens of many different timbers. Collection of material from all States is still contining and the tests are designed to show the extent to which decay resistance is affected by locality of growth, variation between trees, and position within the tree. This project is partly a co-operative one with the Division of Entomology, Canberra, where a parallel series of tests is being made on the same material, to determine resistance to termite attack (*see* Chapter IX., section 13).

In addition to work on Australian timbers, several little-known imported timbers, offered for sale as rail sleepers, have been tested to determine decay resistance.

Work on the collection, identification, and cultural characteristics of Australian wood-destroying fungi is continuing steadily. Field collection of fruiting bodies of these fungi has been expanded during the year and approximately 130 persons in all States are now forwarding material which is rapidly enlarging the herbarium and the standard culture collection. Concurrently with this work the cultural characteristics of wood-destroying fungi are being studied to enable identification of these fungi when a fruiting body is not available. As a further method of identifying wood-destroying fungi in culture, methods of producing fruiting bodies in the laboratory have been developed with reasonable success.

(*h*) *Timber Borers.*—Study of the habits and tl methods of control of the *Lyctus* and *Anobium* bore is continuing. Detailed observations have been mac with *L. brunneus* on oviposition and development of tl egg until emergence of the larva, using a techniqu which permits continual observation of the egg witho disturbance. Studies on oviposition in *Anobium* hav also been made, with particular attention to the typ of surface preferred by the female beetle.

Work on the relative susceptibility of Queenslan rain forest timbers to the *Lyctus* borer has been commenced at the request of the Queensland Forestr Department. A large group of little-known timber has been received for these tests, which are now i progress, and will ultimately include approximatel 160 different timbers (*see* Chapter IX., Sectio 18 (*b*)).

The degree of susceptibility of *P. radiata* to th *Anobium* borer is also under investigation in laboratory tests. In these tests the susceptibility of thi timber is being compared with that of baltic pines an New Zealand white pine, with the object of predictin the possible future need for preservative treatment.

(*i*) *Other Investigations.*—Other work during th year has included the pressure treatment of timbers fo test in water cooling towers, in radio masts, and a ver boarding over drains. Work has also been done the decay resistance of wood-wool cement boards, d on the weather resistance of different preservatives ed for surface protection of sheds, fences, &c.

7. Timber Seasoning.

(Division of Forest Products.)

(a) *General.*—The year's work was characterized heavy demands from industry for technical sistance. A marked change was observed in the atti- de of industry to the various factors affecting the onomics of timber seasoning. Because of the high st of timber, increasing interest was shown in dry- g equipment which would reduce expenditure on r seasoning stocks even though this meant an increase both plant and drying costs.

(b) *Veneer Drying.*—A study of the mechanical ying of veneers of the refractory "ash" eucalypt oup was commenced. It includes a comparison of e values of platen drying, roller drying, and ortho- ox kiln drying. Variables examined during platen rying include (i) "dwell" time, (ii) "breathe" me, (iii) platen pressure, (iv) temperature. For -in. thick veneers, good quality was obtained by ombining a temperature of 320° F. with "dwell" mes ranging from 3 to 15 seconds and a "breathe" me of about 5 seconds over a total time of about 4 inutes. The work completed showed the quality f veneer obtained under optimum kiln conditions, or a roller drier, to be somewhat better than that of he best sheets obtained under platen drying.

(c) *Drying Studies.*—A numerical system of assess- ng drying degrade was evolved in which the severity f each defect was weighted according to its relative mportance. The period over which free evaporation ates are obtained during the drying of green timber nder Australian standard schedule conditions was etermined. This period was shown to be some 4 ours for the heartwood of *Pinus radiata* and *Eucalyptus regnans* when in the form of 1 inch thick oards. The information is important in the design f timber driers. Studies of the moisture content of ardwood railway sleepers in service track in south-east Australia showed that core values remain at about 30 per cent. throughout the year, but that ase values have a wide seasonal fluctuation. Kiln schedule studies were commenced on *E. fastigata*, *Bruguiera* spp., *Rhizophora apiculata*, *E. macrorrhyncha* and a *Swietenia* grown in Fiji. Limited studies were made to determine optimum kiln conditions for wet papier mâché and foamed latex products.

(d) *Vapour Drying.*—Work on the partial drying of 8 by 4-in. sleeper sections of *E. obliqua* to give surface zone moisture contents less than 30 per cent. was continued. "Stanvac K9" and perchlorethylene were used as drying agents. The quality of drying was somewhat better than usually obtained by air drying to similar moisture limits. Preservation treatment with creosote at a pressure of 1,000 lb./square inch to refusal point gave total penetration to a depth of 1 inch from the sleeper surface. Creosote absorption approximated 9 lb./cubic foot. The combined vapour drying and low pressure preservation treatment of green 9 by 6-in. *P. radiata* sleepers required some 10 hours only. Creosote absorption values ranging from 7½ to 10 lb./cubic foot were obtained with heartwood penetration of ¼-½ inch. Sapwood was completely penetrated.

(e) *Kiln Design and Plant Layout.*—Eighty-seven visits were made to commercial plants in all Australian States, to advise on plant reorganization and layout, timber handling and storage, kiln installation, control, and maintenance, the drying of veneer and solid timber, and the prevention of distortion in timber (particularly pre-cut housing timbers). Numerous discussions relating to the design of kilns, conditioning rooms, re-drying rooms, and reconditioners were held with members of industry, and 387 kiln drawings were issued to commercial firms and other organizations in Australia and New Guinea, and some in New Zealand, Malaya, and India. Appropriate specifications and comprehensive materials lists were prepared in most cases. Plant layout plans were prepared for some fifteen firms. Designs for McCashney burners were prepared for 52 firms in all Australian States and South Africa, and performance tests were carried out on a number of constructed units to ensure satisfactory operation.

Particular attention was given to developing designs for pre-driers. These large, multi-line driers were required for operation at constant drying conditions so that any drying line could be unloaded, or reloaded with green timber, at any time without affecting the efficiency of the unit. They will be of value for partially drying the difficult, collapse-susceptible species in the cooler, wetter areas of Australia where preliminary air-drying conditions are unsatisfactory. Estimates indicate that the capital outlay in constructing and stocking such units in these areas will be only about 50 per cent. of that required for building and stocking air-drying yards of equivalent output. Two units with charge capacities of 224,000 and 168,000 super. feet are in construction in Tasmania. Designs were completed for two others with charge capacities of 160,000 super. feet each.

(f) *Waste Wood Products and Building Materials.*—The value of decayed heartwood as a binder for sawdust-based hardboard and briquettes was investigated. Appreciable quantities are present in old trees of the "ash" eucalypt group. With sawdust moisture content below 5 per cent., pressure at 3,000 lb./sq. in., 10 per cent. of the binder, and temperature at 400° F., good briquettes were obtained which resisted crumbling under fairly severe handling. The material proved of little value as a binder for hardboard when pressed at 500 lb./sq. in. At the request of a manufacturer pressing sawdust-phenol resin boards on a semi-commercial scale, comprehensive mechanical and physical tests were made to determine the board characteristics. Recommendations were made on pressing techniques and possible markets. An examination was made of plant requirements for a company proposing to purchase Australian rights for overseas equipment to produce waste wood-resin board in Victoria. At the request of architects and home builders recommendations were prepared on finishing treatments for sawdust-cement floors and for the manufacture and use of wood wool-cement building slabs.

(g) *Other Investigations.*—Methods suitable for field use in measuring the moisture content of tannin barks were examined, and brief studies made of the suitability of moisture meters with special electrodes. Equilibrium moisture content values for wood to cover the high temperature range 212–400° F. were compiled and charts prepared to show values for humidities ranging from zero to saturation over this temperature range, with and without admixture of air. Limited studies were made of E.M.C. values in a freezing chamber. Limited studies were also made of new timber coatings, the drying of turned wooden bowls, the influence of moisture content on corrosion of metal parts in wood packages, chemical seasoning, flue gas heating, temperature distribution in commercial reconditioning chambers, the cost of kiln drying, the drying of plaster of paris, and the design of diffuser screens for laboratory and commercial kilns.

The correspondence course on kiln operation was continued; 24 students were enrolled and thirteen students completed courses.

8. VENEER AND GLUING.

(Division of Forest Products.)

(*a*) *Veneer Cutting and Utilization.*—Reduced supplies of Australian veneer logs have caused increased interest in several eucalypt species for plywood manufacture. Further investigations on alpine ash and mountain ash show that plywood of good mechanical strength can be produced, but owing to the prevalence of splits in peeling blocks, to the susceptibility of veneers to splitting in handling, and to drying difficulties, the percentage of cabinet plywood is small. On the other hand a satisfactory market for case plywood or for structural plywood might be developed; alternatively, ash eucalypt veneers might be used for inner plies and backs to face veneers of other species. Other Australian timbers investigated included rose gum, plantation grown hoop pine and radiata pine, and two New Guinea species *Pentaspodon* sp. and *Melanorrhoea* sp. Methods for the evaluation of veneer quality have been studied.

(*b*) *Adhesives for Labels for Fruit Cases.*—Following representations from the Department of Commerce and Agriculture, laboratory and field investigations to study adhesion and service of labels for export fruit cases have been continued. It has been shown that much of the past trouble was due to the use of unseasoned timber and to improper preparation of adhesive pastes and application of labels to the cases. A standard, S.A.A. (Int.) 370—" Adhesives for Fruit Case Labels ", based on this investigation, was published in January, 1953, and a code recommending techniques to be used in applying labels is being prepared.

(*c*) *Silvicultural Treatment for Production of Veneer Logs.*—Collaboration with State Forestry Departments was continued and further observations were made on the quality of veneer derived from pruned and unpruned logs of hoop and radiata pines.

(*d*) *Immunization of Plywood against Insect Attack.*—Commercially produced plywood containing benzene hexachloride in the glueline continues to resist attack by *Lyctus* borers after two and a half years' service testing. A new investigation on the manufacture of plywood from veneers immunized against termite attack has been commenced in conjunction with the Preservation Section.

(*e*) *Adhesives.*—(i) *Mechanism of Coagulating of Protein Solutions.*—Various physical and chemical investigations were made into the clotting of milk by the enzyme rennet. The liberation of proteoses was confirmed, but their presence does not appear to be essential for clotting, nor are proteolysis or denaturation considered to be essential steps. Observations were made on the role of organically bound phosphorus in clot formation, on the solubility and ultraviolet absorption of casein and paracasein, and on their absorption spectra after reaction with diazotized sulphanilic acid. Attention has also been given to the mode of action of the calcium ions on paracasein during clotting. From the effect of ionic strength and anion valency on the rate of clotting and from the stability of the clots it was concluded that the bonds formed are ionic in character.

(ii) *Spectrophotometric Determination of Amino Groups.*—Based on the observation that the compounds formed by the reaction of glycine and lysine with diazotized sulphanilic acid exhibit absorption maxima in the near ultraviolet, a spectrophotometric method has been developed for estimating amino groups. Oth
groups contribute to the absorption of the protein
363 mμ, but in many studies of a comparative natu
such as following the course of hydrolysis, deaminati
the action of a proteolytic enzyme or of pepti
synthesis, such interference may not be relevant. T
determinations can be made simply and rapidly, a
the method appears to have certain advantages.

(iii) *Reduction of Cystine by Sodium Bisulphite.*
A correct interpretation of the mechanism of t
reduction of cystine by sodium bisulphite is the bas
for a common method for the determination of su
phydryl and disulphide groups in proteins. Expe
ments have been carried out, using spectrophotometr
techniques, which indicate that the usually accept
mechanism may require revision.

(iv) *Kinetics of Rapid Reactions.*—A kinetic tre
ment has been developed, in collaboration with t
Section of Mathematical Statistics, which perm
the ratios between the velocity constants of the vario
stages of the reaction between a potentially bifur
tional molecule and a unifunctional molecule to
determined from observations of the initial conce
trations of the reactants and the final concentratio
of the reactants or products. The treatment is gener
and allows virtually " instantaneous " consecuti
second-order reactions to be resolved kinetically in
their component steps. As an experimental method
determining relative velocity constants, the work shou
be of use in theoretical organic chemistry in providi
data against which different methods of correlati
structure and reactivity can be tested. It has be
suggested that the method might be applicable
peptide hydrolysis and peptide synthesis.

(*f*) *Other Investigations.*—(i) *Storage of Undri*
Casein.—Systematic tests showed that, where no faci
ties for casein drying exist, undried casein can
stored for at least nine months at temperatures
−1 or 15° F.

(ii) *Urea-formaldehyde Resin Glues Extended w*
Wheaten Flour.—Flours from wheat varieties of l
gluten content and low gluten strength, commercia
available as biscuit flour, are best for extension of ure
formaldehyde glues as they require the addition of
minimum amount of water to produce a suitable v
cosity. New South Wales and Queensland samp
gave higher viscosities when suspended in water or
resin and water mixes than did Victorian flour. T
pot life at 25° C. of flour extended resin mixes
five to ten times that of the unextended resin. Th
increase in pot life with flour extension may be i
portant in hot weather when the life of an unextend
resin is inconveniently short.

(iii) *General.*—Assistance was given to the Sta
dards Association of Australia in drafting specifi
tions for plywood and glues, and to Commonwea
and State Government Departments, private enterpri
and householders on: plywood manufacture, plywo
and glues for furniture, moulded plywood, constr
tion of D.M.E. masts and other laminated assembli
corestock, prefabricated structures, caravans, boa
diving boards, doors, glue identification, and sporti
goods. Towards the end of the year the work
veneers and gluing was restricted and some of
Section's staff were transferred to other work.

9. TIMBER UTILIZATION.

(Division of Forest Products.)

(*a*) *Timber Uses.*—Inquiries continued at a hi
level and information was supplied on timbers
some hundred uses and data were supplied on
properties of some 65 species.

b) *Manufacturing Processes.*—Interest in designs plants to manufacture wood products was main- ed. Layouts were prepared for fifteen sawmills, a ssing plant, five joinery works, and a case plant. wings were prepared for a portable sawmill suit- for operation by personnel of the armed forces progress made in preparing notes on the sawing ctices to be adopted with it. Advice was given on duction techniques and on the sawing of planta- -grown hardwoods. A double-sided saw bench ge was described and this stimulated widespread erest.

nformation was supplied on bandmills, gangsaws, me-saws, splitting saws, splitting guns, log-edgers, ial arm saw benches, double-friction saw benches, dworkers' universal saw bench, jointers, slicers, king machines, dockers, firewood slashers, firewood ches, transmission equipment, hydraulic drives, feed hanisms, sawdust conveyors, and stapling machines. wmills were visited in Victoria and Queensland. vice was given regarding self-loading trucks, cable ging for moving logs in mill yards, and guards for ctors. A lecture on logging was written for the yal Australian Air Force.

Other problems dealt with concerned the staining, aching, liming, and polishing of timber; painting, ing, and natural finishing of weatherboards; pro- ng and finishing of flooring; the under-heating of ors; pre-forming of room units in plaster; construc- n of log cabins; fabrication of flush floors; the treat- nt of crates affected by moulds; packing of heavy achinery; prevention of or cure for corrosion of ated machinery and of metal fastenings; manufacture dimension stock, corestock, musical instruments, and odel propellers; bending of staves; plugging of knots, ot holes, and pith; manufacture of pulp and paper; oduction of wood flour; and production of wood ol.

(c) *Waste Utilization.*—The wider use of wood aste as a fuel was encouraged, advice being given garding conditions for efficient combustion and designs epared for sawdust-burning furnaces for attachment boilers of low steam rating in four saw-mills. A nited study was made on pine bark to evaluate it as fuel. Data regarding the briquetting of wood waste re distributed and assistance was given to a firm deavouring to market a briquetting machine. Notes general uses of sawdust were distributed. Recogniz- g that one of the disadvantages of sawdust in the il was its depleting effect on the nitrogen content of e soil, experiments were carried out to determine ether simple pre-treatments of sawdust could lessen e effect. It was found that sawdust hydrolysed to ve more than 30 per cent. alkali solubles caused an crease in nitrate, but when the alkali solubles were s than 30 per cent. nitrates were depleted. Following sts on methods of attaining 30 per cent. alkali lubility, 1 ton of hydrolysed sawdust was prepared r use in field trials designed by the Victorian Soil nservation Authority.

From a 1952 series of tests no marked difference peared between grapes packed in sawdust and in anulated cork after long storage in Australia, and conclusive reports were returned on sawdust-packed ses exported to Singapore. In the 1953 experiments, wdusts of radiata pine, mountain ash and jarrah, a aterial derived from bark of *Melaleuca* sp., and cork, ve been used to pack export quality grapes. Some of e cases have been transported to cool stores in Sydney d others shipped to Singapore. Inspections on a mparative basis will be made early in the coming ar.

Sawdust from *Eucalyptus regnans* was separated into fine and coarse fractions. The products from ball-milling the fine fraction and attrition grinding the coarse were mixed and converted into wet pressed hardboards and some of these were of attractive appearance. The laboratory procedures for mixing pulp and pressing were improved, and hardboards of commercial strength were produced by dry pressing although wet pressing gave still higher strength. The effect on strength, density and moisture content of additions of sulphuric acid and linsed oil were studied.

(*d*) *Sawing.*—Sawing chains of the "scratch" type were sharpened with three different angles of hook on the outer cutting teeth and with three raker clearances and rates of sawing and power consumptions are being determined in timbers of low, medium and high density to provide data for sharpening schedules. Initial trials with overseas "chipper" type chains indicated the need for modifying the gauging teeth for Australian eucalypts, and this is proceeding. To supplement a trade circular, instruction sheets, and journal articles, a script has been drafted for an instructional film on sawing chains.

Tests have continued with the experimental circular saw bench. Information was distributed on safety-type circular saws, on carbide-tipped saws, and on the sawing characteristics of some Australian timbers.

(*e*) *Standards.*—Collaboration with the Standards Association of Australia was continued on matters concerning timber standards. Executive duties were undertaken for the Timber Industry Committee and Sectional Committees, and technical assistance given in preparing and reviewing drafts of proposed standards. Interim standard grading rules were published by the Association for rough sawn hardwoods of eastern and south-eastern Australia, and for rough sawn brushwoods of eastern Australia. Australian standard specifications were published for waterproof plywood, marine and standard grades, and for fibreboard containers for butter. Progress was made in the preparation of specifications for furniture plywood, synthetic resin-adhesives, protein adhesives; of revised grades for milled flooring, lining, and weatherboards of radiata pine and hardwoods of south-eastern Australia; and specifications for poles, piles, sleepers, structural timbers, and crossarms of eastern Australian hardwoods. The revision of the Australian standard nomenclature of Australian timbers was commenced and assistance given in drafting and reviewing a nomenclature of timbers imported into Australia. A pre-committee draft specification was prepared for wood treated with lycticides. Work was initiated concerning standards for wallboards, and field records collected by the Department of Forestry, Queensland, on the grading of sleepers were analysed.

XV. BUILDING.

1. GENERAL.

The building research work of the Organization is undertaken mainly by the Division of Building Research at Highett, Victoria, which collaborates closely with the Commonwealth Experimental Building Station of the Commonwealth Department of Works in New South Wales. Research is directed towards the study of the more effective use of available materials, the adaptation of traditional materials to new constructional methods, and the development of new materials and building techniques for the improvement of both the functional aspects of buildings and the efficiency of methods of construction. The work of the Division is reported in this Chapter.

Work on timber for constructional purposes is concentrated in the Division of Forest Products (*see* Chapter XIV.). Work on house foundations is undertaken by the Division of Soils (*see* Chapter II., Sections 3 (*h*) and (*k*)) and work on cement and ceramics is undertaken by the Division of Industrial Chemistry (*see* Chapter XVIII., Section 4.)

Division of Building Research.—No major changes were made in the research programme of the Division during the year but greater emphasis was given to the work on lightweight aggregates and the use of plaster of paris as a structural material—developments that show considerable promise of reducing the costs of building. Inquiries received numbered 2,700, an increase of 8 per cent. over the figure for the previous year. Although inquiries from private individuals and manufacturers still predominated, there was a marked increase in requests received from architects and engineers. As in previous years liaison was maintained with the various branches of the building industry, the Standards Association of Australia, and Commonwealth and State Departments. Courses of lectures were delivered to students of the University of Melbourne and the Melbourne Technical College.

2. LIGHTWEIGHT AGGREGATES.

(Division of Building Research.)

Considerable attention has been devoted to the production of lightweight materials suitable for use as aggregates in concrete and plaster. The most promising of these are bloated clays, perlite, and vermiculite.

(*a*) *Expanded or Bloated Clays.*—Tests on clays and shales from Melbourne, country areas of Victoria, Queensland, and New South Wales have shown that satisfactory aggregates can be made by heating the raw materials in a rotary kiln, with or without bloating agents such as haematite or calcium carbonate. The use of these aggregates in concrete has been investigated. It has been found that the density of the concretes ranges from 96 to 115 lb./cu. ft. when wet and 78-100 lb./cu. ft. when dry. The compressive strength of six-bag mixes at 28 days ranged from about 2,000 to 5,000 lb./sq. in. The flexural tensile strengths were about one-ninth of these figures. Ground diatomite, 30 per cent. by weight of the cement, added to a six-bag mix increased the compressive strength from about 2,300 lb./sq. in. to about 4,200 lb./sq. in. and increased the wet density from 96 to 115 lb./cu. ft. A ten-bag mix had a compressive strength between 4,500 and 5,000 lb./sq. in. Such strengths are of the order of those required for prestressed concrete.

The shrinkage of the ordinary six-bag mixes has been of the order of 0.06 per cent. which is approximately what would be expected from the corresponding dense mixes.

(*b*) *Perlite.*—Information has been collected on the distribution in Australia of the glassy volcanic rock obsidian from which the expanded lightweight aggregate perlite is made. Exposures of the material, chiefly in southern Queensland and northern New South Wales, were visited and samples collected. A vertical furnace to expand the material on a pilot-plant scale has been designed and constructed. Perlite of density as low as 3 lb./cu. ft. has been produced, but no extensive testing is possible until larger supplies are available. A horizontal furnace as an alternative pilot-plant means of producing the material is being constructed.

(*c*) *Vermiculite.*—Attempts to use a sample of local vermiculite as a plaster aggregate have resulted in unsightly efflorescence which has been attributed to insufficient heating of the raw vermiculite in the expanding process. Tests on material from two deposits treated in another plant have supported this explanation. The finer portion of both materials gave little or no trouble, but the coarser caused serious efflorescence. Visual examination of the coarse material revealed incompletely exfoliated pieces.

3. CONCRETE INVESTIGATIONS.

(Division of Building Research.)

(*a*) *Theory of Rupture of Concrete.*—As part of t
long-term study of the mechanism of failure of concre
under load, experiments have been carried out to inves
gate the complex strain systems existing on the surfa
of various types of test specimen.

In the method used, a blanket of closely spaced ele
trical resistance strain gauges was applied over t
surface. D.C. measuring equipment has been fou
unsuitable for these gauges owing to the magnitude
thermal effects in the circuit, but consistently relia
results can be obtained by the use of A.C. equipment.
new adhesive, a proprietary acrylic resin, has been us
successfully to attach the gauges to dry concrete, a
attempts are being made to evolve a more rapid agi
process so that it can be used with moist concrete.

To investigate the stresses in an inclusion of o
elastic material in another so that the relation betwe
the strength of an aggregate and the strength of concre
made with it may be determined, investigations a
being carried out to determine relations between stre
functions involved in a three-dimensional homogeneo
isotropic elastic medium in equilibrium.

Tests on unreinforced beams, slabs, and disks
bending have shown that cracking does not propaga
instantaneously in concrete. There is a measural
difference between the load at which cracking begi
and its ultimate load. Strain measurements show
considerable variation in the elastic properties of t
concrete throughout a specimen. Tests were therefo
carried out to find to what extent such variation w
due to variations in moisture content and temperatu
It has been shown that both Young's modulus a
Poisson's ratio drop markedly as concrete dries, or
the temperature of a specimen increases. It has a
been found that the tensile strength of saturat
concrete at 40° C. is about 75 per cent. higher than it
at 60° C. Such factors undoubtedly influence t
durability of exposed structures.

(*b*) *Foamed Concrete.*—Investigations on foam
concrete, which is now being manufactured in t
country, have been continued with the object of impr
ing its physical properties, particularly its dimensio
stability (freedom from shrinkage) and its streng
Tests with artificial drying to determine the relation
drying shrinkage to moisture content are bei
continued.

The effect of particle size, grading, and vibration
strength are being studied.

Work has been done also on cellular calcium silic
—a potential material for structural units. This
made by autoclaving a prefoamed mix of lime and sil
flour. The amount of lime needed depends on t
specific surface of the silica, that is, it is greater t
finer the sand. An expression for the optim
lime : silica ratio has been derived.

A compressive-strength : density ratio of 60 has be
obtained with densities of about 60 lb./cu. ft. T
ratio is about four times that of ordinary concrete a
up to 50 per cent. higher than that of high streng
concrete such as is used for prestressing.

4. GYPSUM PLASTER AND PLASTER PRODUCTS.

(Division of Building Research.)

(*a*) *Reinforced Gypsum Plaster.* — (i) *Bo*
Strength.—The bond strength between steel reinforci
bars and gypsum plaster was found to decrease w
increasing length of embedment and with increasing b
diameter. The addition of either lime or sand had
significant effect, but together they affected the streng
in an erratic and unexplained way.

ii) *Wall Units.*—Small panels of reinforced gypsum ls were tested under central and eccentric concen- ed and distributed loads. Panels tested after being ed to constant weight were much stronger than those ed wet.

b) Setting of Gypsum Plasters.—(i) *Measurement Setting Time.*—For correlating the various methods letermining setting times, the setting times of two nmercial plasters retarded with various amounts of ic acid were measured by five different methods. hough the two plasters were retarded to different ents, the results of all five methods were affected ilarly even though two measured surface hardness the others resistance to deep penetration, tendency the plaster to flow, and the evolution of heat of lration respectively.

ii) *Crystallization of Gypsum.*—Crystallization of sum from dilute suspensions of plaster was shown microscopic examination to be well advanced before temperature rise, usually considered to be caused by formation of gypsum, of a normal mix would have un.

c) Density and Structure of Plaster of Paris.—The sities of fine powders are usually measured by deter- ing their weight and the volume of a suitable liquid ich they displace. When the densities of plasters e been determined in this way the results have ended to some extent on the liquid used. This gests that the particles of plaster may contain micro- pic pores accessible to some molecules but not to ers, thus giving a falsely high value for the volume the sample.

he densities of plasters have been determined with h toluene and air as the displacement fluids. The ults show that between 5 and 7 per cent. of the arent volume of the plasters examined consists of es accessible to oxygen or nitrogen molecules but not he larger toluene molecules.

d) Weatherproofing of Plaster Slab Walls.—Tests nake plaster slab walls weatherproof by casting them sheets of asbestos cement showed that adequate bond ld be obtained in small specimens, but not in large cimens, which failed because of differential move- nt of the two materials during drying. Specimens which plaster had been gauged with a bitumen ılsion were an exception, however, and tests on these continuing.

e) Decoration of Fibrous Plaster.—Experimental k undertaken between 1948 and 1952 has been ated and it is now established that "flush joint" or phide staining on fibrous plaster usually results m the combined use of lead-containing compounds proteinaceous water paints. Cement sealers, therproof oil, and similar materials containing lead ers can introduce sufficient lead to cause staining.

5. LIME AND LIME PRODUCTS.

(Division of Building Research.)

a) Correction of Unsoundness in Magnesian Limes. he reactions between magnesium and calcium oxides their chlorides, on which the correction of unsound- s in limes is based, have been studied. It has been ablished that there are two stable crystalline mag- ium oxychlorides, $5Mg(OH)_2.MgCl_2.xH_2O$ and $g(OH)_2.MgCl_2.xH_2O$, and one calcium oxychloride, $a(OH)_2.CaCl_2.xH_2O$; the stability fields of these npounds have been determined. The studies on the stal structures indicate that there are differences in structure of $3Mg(OH)_2.MgCl_2.xH_2O$ from that pro- ed by overseas workers.

(*b*) *Sand-lime Bricks.*—Walls of a laboratory building, of single-brick thickness, serving as panels for investigating the durability and other properties of sand-lime bricks, show no signs of water penetration even in that part built without a dampproof course.

6. CLAYS AND CLAY PRODUCTS.

(Division of Building Research.)

(*a*) *Survey of Heavy Clay Industry of Australia.*—The survey of the clay resources and heavy clay industry of the provincial cities and country areas of New South Wales and Victoria was completed.

The raw materials are drawn from deposits of all geological ages and vary from hard metamorphic schists through shales and mudstones to soft plastic clays, and from pure white kaolins to highly coloured ferruginous and siliceous materials.

In Victorian country areas fourteen of the 34 brickyards use the stiff plastic process typical of Melbourne, but only three yards operate the semi-dry process typical of Sydney. In New South Wales 53 of the 89 country brickyards have adopted the semi-dry press whereas only one operates a stiff plastic machine. Forty-three country works in the two States use the extrusion process so little used in the cities. Ten works in New South Wales still make bricks by hand.

(*b*) *Clay Research.*—(i) *Constitution, Properties, and Behaviour of Clays.*—X-ray and differential thermal analysis of the clay minerals show that the Hawkesbury and Wianamatta shales of the Sydney area are essentially similar and all contain kaolinite and illite. The Lower Wianamatta shales, distinguished by their high content of impure siderite, are too difficult to extrude but are well suited for the semi-dry press process. It is not economically feasible to improve the olive-drab colour of bricks from these shales.

The plastic limit for materials capable of extrusion has been shown to be closely related to particle size distribution; proportions for sand, silt, and clay in mixes have been defined which represent ideal, acceptable, and unsatisfactory conditions for both extrusion and drying.

Studies of the melting point and other high temperature reactions as determined by differential thermal analysis (D.T.A.) and deformation-under-load tests reveal interesting relationships between the reactions and the stratigraphic origin of the materials. Tests indicate that the geological sequence in the Sydney area can be subdivided in greater detail than has been arrived at during geological mapping.

For assessing the effect of the crystallinity of kaolinite on its thermal reactions, seven "pure" samples of kaolinite were divided into three particle-size fractions. Attention has been confined to the fraction which showed from its D.T.A. curves no size effect.

D.T.A. curves obtained for the colloid, coarse clay, silt, and sand fractions of some twenty clays have shown that clay minerals are by no means confined to the finest fractions. Sometimes they are present in even greater amounts, not only in the silts but also in the fine and coarse sands.

In an examination of the sodium sulphide method for determining free oxides and hydroxides in clays and for their removal therefrom, D.T.A. curves have been obtained for samples before and after treatment. The curves show the extent to which the non-clay minerals have been removed and indicate more clearly than chemical analyses the effect of their removal on the clay.

(ii) *Rehydration of Burnt Clays.*—Kaolinites burnt to over 500° C. and then rehydrated have been found to have a high strength which might be important industrially.

(iii) *Deterioration of Roofing Tiles.*—In co-operation with the Roofing Tile Manufacturers' Association of Victoria an investigation into the Australia-wide problem of the deterioration of terracotta tiles on roofs facing sea fronts has been started.

(*c*) *Clay Technology.*—Samples of clays from all States and also from Papua and Pakistan have been examined in the pilot plant and the industrial potentialities of the clays assessed. Experimental work on the Wianamatta, Hawkesbury, and post-Tertiary clays and shales from Sydney is continuing. It has been established that some plastic clays which were unsatisfactory when extruded under normal conditions extrude well after de-airing. Tests have been carried out on the fast drying and correction of excessive drying shrinkage of plastic clays.

7. CAULKING COMPOUNDS.

(Division of Building Research.)

(*a*) *Fundamental Rheological Studies.*—(i) *Oil-based Caulking Compounds*—Measurement of the flow properties of precipitated calcium carbonate of known particle size distribution in a polymerized linseed oil showed that departure from Newtonian behaviour occurs only at the concentration when all the voids in the powder are just filled with oil. A relation between the relative viscosity and the concentration, and the presence of structural viscosity, have been established. Some measurements with various asbestos fibre dispersions in the same vehicle showed that the longer the fibre the higher the yield value.

(ii) *Two-component Internal-set-up Mastics.*—Samples of two-component internal-set-up mastics from the United States of America, where they are used extensively for sealing joints in concrete canal linings, have been examined. The rheological properties of dispersions of various bitumens in various oils are being studied with a view to producing a satisfactory mastic from materials available in this country.

(*b*) *Investigation of the Gun-extrusion Properties of Joint-sealing Compounds.*—The rheological study of the gun-extrusion properties of certain joint-sealing compounds suitable for use in canal linings was completed and a report on the investigation, embodying tables for the prediction of extrusion pressures under conditions likely to be met in practice, is awaiting publication.

(*c*) *Laboratory Durability Studies.*—An investigation begun in December, 1949, on the performance of joint-filling materials placed between the paving slabs of a simulated promenade roof deck was completed. In this test mechanical performance was regarded as a criterion no less important than water exclusion. The final condition of the materials was assessed by lifting the slabs and examining the seals in profile. The best all-round results as a joint-filler were obtained with a filling of standard H20/30 fluxed Trinidad asphalt. Fibrated bituminous cements (cutbacks) were generally effective even though shrinkage and bond loss beneath a hard crust were common. Mixtures of bitumen and rubber prepared from emulsions gave disappointing results mainly on account of re-emulsification. Hot-fill blown bitumens were in general very brittle and unsatisfactory.

(*d*) *Field Studies.*—Studies of the experimental joint seals in the State Rivers and Water Supply Commission's main irrigation channel at Rocklands, Victoria, were concluded and it was recommended to the Commission that the joints in the 2½-mile bench flume section should be pointed with a fatty acid pitch mastic applied over a barbed rubber water-stop.

A report on overseas practice in the sealing of jo in concrete canal linings has been prepared and s mitted to the State Electricity Commission of Victo who requested the data, and to other interested bod A visit was made to the Kiewa works area to study performance of existing joint seals in the Bog Creek race line after twelve months' exposure. T proprietary materials were used here—one based rubber bitumen and one based on fatty acid pi Of these the former was in better condition.

8. CONCRETE FLOOR SURFACES.

(Division of Building Research.)

As an extension of the experiment to determine effect of different floor surfaces on the foot temp tures of test subjects in a controlled-temperature ro the relation between these temperatures and foot c fort was determined by recording the reactions of subjects when seated with their feet placed on c crete slabs which were either bare or surfaced w cork tiles. The impressions were then compared w the foot temperature.

Eleven out of fifteen subjects gave the same relat between temperature and comfort for the two f surfaces, showing that the temperature is the c thermal factor affecting the comfort. For the ot subjects the comfortable temperature on the two flo was the same, but greater changes in temperature co be tolerated on the cork floor for a given discomf that is, the subject was always less comfortable on concrete. This effect is almost certainly due t metal bias and not to thermal factors.

9. BITUMINOUS ROOFING MATERIALS.

(Division of Building Research.)

(*a*) *General.*—Work on problems relating to performance of bituminous roofing has continued, w special attention being given to the practical asp of roof construction.

(*b*) *Laboratory Studies.*—(i) *Roof Surface T peratures.*—Analysis of data from records of r surface temperatures on an experimental build was completed.

(ii) *Bituminous Adhesives for Built-up Roof C struction.*—In the choice of bitumens for built-up r construction current Australian practice differs fr the standard practices of some overseas countries, experiments have been undertaken for compar materials. These experiments incorporate both labo tory tests and pilot-scale application trials from wh estimates can be made of the "pourability" and spre ing rates of bitumens over a range of temperatu and also of the toughness of the bitumen bond.

Small variations in temperature of the bitun markedly affect the rate of application and prolon heating at high temperatures causes embrittleme stringent steps should therefore be taken by roo contractors to maintain the bitumen as near as poss to the optimum temperature.

(iii) *Experimental Roof Membranes.*—Deta inspections have been made of the experimentally l roof membranes constructed in the grounds of Division and elsewhere in Melbourne over the p five years. The performance of membranes construc with asbestos fibre felts and coated with a single ap cation of bitumen and aluminium paint has been c sistently good and markedly better than the correspo ingly (saturated) rag felt membranes which h shown extensive puckering. The conventional coa rag felt membranes are in general in good conditi No corrosion is apparent in the aluminium membranes.

(iv) *Field Investigations on Flat Roofing Problems.* Frequent inquiries on flat roofing problems continue be received. One inquiry related to leaks in a paved mbrane of one of the Organization's own buildings d flooding tests have been carried out to locate these ks. The defects have already been shown to be due part at least to inadequate parapet flashing.

Further evidence has come to hand on the defects high-purity lead as a flashing material, failures by tigue and occasionally corrosion by cement mortar ing the usual troubles. It is thought that wider use low-alloy leads would reduce the frequency of fatigue ilures.

10. THERMAL INVESTIGATIONS.

(Division of Building Research.)

The factor which is at present the major unknown the calculation of temperatures in buildings is that ie to the radiation falling on the structure. Experi- ents have shown that the temperature of air $\frac{1}{4}$ inch om the surface of a sunlit building can be as much 25° F. above the shade air temperature because of blanket of warm air, the effects of which are little iown. The changes due to the size and nature of the irface and to the wind are being studied.

Preliminary tests of thermal conductivity have been ade in the 12-in. guarded hot-plate apparatus which is been under construction. Trials are now being ade to ensure the correct functioning of the icillary apparatus.

11. ARCHITECTURAL ACOUSTICS.

(Division of Building Research.)

(*a*) *Subjective Acoustics.*—There is no known test iat may be applied to ascertain with certainty the kely subjective reaction of an audience to the coustics of any enclosed space. A better test than ie reverberation time test, which is far from satis- ictory, might arise from a consideration of the echo ittern since ordinary sounds all consist of a direct und followed by a succession of echoes.

Laboratory studies have been made by adding arti- cial echoes to sounds recorded with little or no echo. he results obtained from a group of subjects who ere asked whether they were disturbed by the echo for umerous combinations of echo level and delay corre- ond fairly well with previously expressed ideas for sign of cinemas. They are, however, considerably fferent from similar suggestions for the requirements live-artist theatres and tests have been made to solve the reason behind these differences.

(*b*) *Acoustic Absorption.*—The absorption coeffi- ent of acoustic materials can be calculated from ipedance results and it has been decided to test aterials by measuring impedance by either the ipedance tube or transmission chamber methods. ome developmental work is being undertaken to find method of measuring absorption which would be ell based in theory and reproducible in any boratory.

(*c*) *Ductwork Measurements.*—The calculation of oustic transmission along ducts is extremely tedious id difficult. Studies on possible extensions of the ipedance tube method have led to good progress being ade on the simplification of such calculations.

If a discontinuity such as change of size or direction curs in an acoustic duct and if beyond it all the und be absorbed, then measurements in the input and itput duct lead to simple coefficients which can be used r calculation.

(*d*) *Speech Reinforcement.*—The Division was approached for assistance with the speech reinforcement system at the evening sessions of the 1953 Melbourne Film Festival, held in March at the Exhibition Building. The section of the main hall used had a reverberation time of about five seconds empty and four seconds with an audience of 1,800 persons. For speech in such a hall the optimum reverberation time should be of the order of one to one and a quarter seconds.

Two speaker systems were installed. In the first, one column of speakers at the right hand of the screen was used to direct sound to the whole audience; in the second, similar to that used in St. Paul's Cathedral, London, a column at the screen and a second column half way down the hall and fed with a delayed signal were used. Both systems gave good results.

12. OTHER INVESTIGATIONS.

(Division of Building Research.)

(*a*) *Polystyrene Wall Tiles.*—Tests have been continued on materials sold as adhesives for polystyrene tiles. This work has confirmed the opinion expressed in the Annual Report for 1951-52 that adhesives based on drying oils or resin solutions plus filler were, despite their widespread sale, generally unsuitable.

(*b*) *Efflorescence.*—A study of an extensive salt formation on the inside of an underground concrete tunnel showed that it consisted mainly of sodium sulphate and a mixed sodium carbonate and sodium bicarbonate. These salts arose from the surrounding soil which had been contaminated with sulphuric acid from an old galvanizing plant. There was no evidence of the sulpho-aluminates which appear when concrete is seriously attacked by sulphates, but they are to be expected in time.

(*c*) *Plastering.*—The effect of delayed working on the strength of portland cement mortars is being studied to provide data for a proposed code of practice on plastering. Results suggest that the usually specified maximum time of two hours between mixing and using is unnecessarily short.

XVI. WOOL TEXTILES.

1. GENERAL.

A considerable programme of research is in hand embracing many problems associated with wool in the textile field, and this work is complementary in the field of wool production to the work in sheep and animal husbandry described in Chapters V. and VII. Research is directed to increased knowledge of the chemical, physical, and mechanical properties of wool; to exploitation of the by-products of the wool industry; to improved machinery for wool textile manufacture and improved technology in the chain of processes through which wool passes in the ultimate fabrication of textiles. A major aim of this work is to view the whole field of wool production and bring cohesion and unification to the techniques of wool processing; and if possible to eliminate or modify the less desirable natural properties of wool and thus improve by every means the competitive position of wool relative to synthetic fibres.

Three establishments are now grouped under the Wool Textile Research Laboratories—

(1) The Melbourne Laboratory at Parkville is responsible for chemical and biochemical work.

(2) The Geelong Laboratory at Belmont is responsible for technology investigations.

(3) The Sydney Laboratory at Ryde carries out research on the physical and engineering aspects of wool processing.

Wool wax is a source of considerable potential wealth which has not been fully exploited. The Division of Industrial Chemistry has continued a study of its recovery and utilization (*see* Section 6 of this Chapter). It is also studying protein structure (*see* Section 13 of this Chapter).

The Division of Entomology is studying the digestive processes of wool-attacking insects as part of a fundamental investigation of the problem of protecting wool (*see* Chapter IX., Section 4 (*a*)).

Wool Textile Research Laboratories.—Research at the Geelong Laboratory on problems directly affecting the wool industry has been extended during the past year. Close collaboration has been maintained by this Laboratory with those engaged in the commercial application of the resin shrinkproofing process and with firms manufacturing the L.B.E. branding fluid to ensure that a standard product is marketed by all. Assistance was given to industry in Geelong in the recovery of wool damaged during the Barwon River floods. From the Melbourne Laboratory a new series of publications entitled "Circular to Carbonizers" is now being issued in addition to the "Circular to Fellmongers" series initiated some years ago. The purpose of this new circular is to convey information of practical interest to the carbonizing industry with minimum delay. In the Biochemistry and the Physics and Engineering Units at the Melbourne and Sydney Laboratories respectively, less attention is paid to the immediate problems and processes of the wool textile industry in favour of accumulating chemical and physical data on the properties of wool to provide the manufacturer with data comparable with that already available on the artificial fibres. In previous years attention has been restricted in the Sydney Laboratory to studies of the physical properties of single fibres. Staff is now becoming available to extend this work to the study of fibre assemblies and to the physical principles underlying textile processes. Construction of the main building at Geelong to accommodate laboratories and mill machinery is now well advanced and a limited amount of additional laboratory and workshop space has now been provided at the Sydney and Melbourne sites.

The investigations on the supercontraction of wool fibres are carried out by an officer of the Sydney Laboratory located in Professor A. E. Alexander's laboratory at the New South Wales University of Technology, and X-ray studies on the transformation of α-keratin to β-keratin are being undertaken in the Physics Department of the same institution. An assistant, attached to the staff of the Geelong Laboratory, is helping with studies of crimp in wool at the Textile School at the Gordon Institute of Technology at Geelong, while the Melbourne Laboratory maintains close contact with protein research workers in the Biochemistry Department of the University of Melbourne and has assisted this Department to obtain special equipment for protein research. Collaboration with institutions of higher learning in Sydney, Geelong, and Melbourne not only benefits the Wool Textile Research Laboratories but also serves to draw the attention of staff and students to fundamental aspects of problems of the wool industry. Grateful appreciation is due to the senior staff of the institutions concerned who have made this collaboration possible.

2. BRANDING FLUIDS.

(Wool Textile Research Laboratories.)

Work is being continued at the Geelong Laboratory on L.B.E. branding fluid which is now widely used by graziers. Fluid prepared to the formula of New
L.B.E., with improved resistance to immediate rai
fall, is being made commercially and, as with th
earlier product, no difficulty has been experienced
its removal during processing.

A survey has been made to ascertain the views of th
industry on wool now being received in view of th
wide-scale use by graziers of L.B.E. branding flui
Improvements have been reported in certain sectio
but the full benefits are not yet apparent, owing
the continued use of the older types of sheep-markin
materials. Manufacturers cannot afford the risk
leaving any unscourable brands in their wool an
therefore, still sort all brands before scouring, eve
though such action is superfluous with wool co
taining L.B.E. branding fluid. It has been observ
that brands sorted from wool show 50–60 per cen
less residual stain after scouring than before the intr
duction of L.B.E. This corresponds roughly to t
extent to which L.B.E. branding fluid is used. Fu
benefit from the use of scourable products will on
be obtained when their application is universal.

3. FELLMONGERING.

(Wool Textile Research Laboratories.)

Fellmongering investigations are being continu
at the Melbourne Laboratory. Many firms in Au
tralia and the United Kingdom are using digesti
methods of recovering wool from skin pieces and fro
"weevil-damaged" or extremely ribby skins, based
recommendations issued in 1945 by research worke
now attached to the Melbourne Laboratory. In t
course of further laboratory and works experience t
importance of heat shrinkage of the skin tissues a
vigorous aeration during the subsequent warm-wat
digestion have been repeatedly demonstrated. If t
aeration is adequate a further improvement is effect
by the addition of 0.05 per cent. of calcium chlori
to the digest liquor. In the processing of pieces fro
painted skins which have been delimed with ac
immersion for eight hours in a proteolytic enzy
solution immediately after shrinkage hastens t
subsequent warm-water digestion.

4. SCOURING.

(Wool Textile Research Laboratories.)

Owing to the growing interest in ultrasonic metho
of cleaning fibres, studies have been commenced
the Sydney Laboratory on the mechanism of d
removal by this process. The rising price of so
has stimulated many inquiries during the past ye
on the use of synthetic detergents, and advice
methods of measuring and controlling the pH of sco
liquors has also been provided.

5. SOLVENT DEGREASING.

(Wool Textile Research Laboratories.)

The jet solvent degreasing plant is now in worki
order at the Geelong Laboratory and several batches
wool have been put through the machine. The lano
recovery unit attached to this plant has also perform
well in preliminary trials.

A small laboratory model of the plant was construc
at Geelong to examine the effects of various fact
before the pilot plant was put into operation. Th
laboratory tests have given information on the con
tions that are likely to be most effective on the la
scale.

A suitable line of wool has now been obtained
use in a large-scale combing trial to enable a furth
comparison to be made between the new jet solv
process and normal scouring. The trial reported l
year indicated that the jet process produces a mu
better product.

6. Wool Wax.

(Division of Industrial Chemistry.)

) *Chemistry.*—The Organic Chemistry Section of Division has continued its examination of the iatic alcohols occurring in combination in wool with particular reference to the normal (straight- n) alcohols. There has been some doubt in the past rding the occurrence of such alcohols in wool wax; expected that the present work, using the techniques hromatography and fractional distillation in the ning-band column, will settle the question.

ie acidic components isolated from the natural wax lso under study by reducing them to the correspond- ilcohols, and applying to these the above techniques.

italytic hydrogenation procedures for converting wool-wax acids to the commercially more useful iols have been studied. Small-scale hydrogenations r high pressure (4,000 lb./sq. in.) at temperatures he order of 300° C. in the presence of copper- mite catalysts have given good yields; it has also found possible to reduce the copper soaps without her catalyst. Direct hydrogenolysis of wool wax f under similar conditions has also been studied and d to proceed more readily than the reduction of the s.

arious derivatives of the wool-wax acids have been ared but do not appear to have any immediate strial application.

ome experiments directed towards the preparation odified alkyd resins using wool-wax acids in formu- ons with phthalic anhydride and glycerol have led products which may find a place in the lacquer stry.

) *Recovery.*—The flotation method for recovering wax developed in the Physical Chemistry Section he Division has been modified so that the wax luced is superior to that usually obtained by other iods. The process in its final form consists in ting scour liquors in modified mineral flotation hines, recirculating the froth through the flotation hine impellers to reduce its bulk, and then, after ning the froth in counterflow with water, dispersing n hot alkaline solutions to give a concentrated lsion from which wax is separated by centrifuging. overall recovery of wax from the liquors is approxi- ely 50 per cent. for liquors containing 1.5 per cent. and greater for richer liquors. One Australian rer is already using the process successfully on a mercial scale and wide interest has been aroused in Australia and overseas. The Geelong Labora- of the Wool Textile Research Laboratories is now perating with the Division of Industrial Chemistry ssisting interested firms to install commercial units.

7. Carbonizing.

(Wool Textile Research Laboratories.)

t the Melbourne Laboratory investigations on the huric acid method of carbonizing have shown that ying amounts of acid can remain in the burry wool r passing through the squeeze rollers without the content of the dried wool being appreciably cted. Similarly, the type of wool and its previous tment have little effect on the acid uptake.

8. Wool Drying.

(Wool Textile Research Laboratories.)

Vool is capable of adsorbing over 30 per cent. by ght of water and the water content has a pronounced ct on its physical properties. The laws governing uptake of water by wool are not satisfactorily estab- ed and information on the rate and heat of adsorp- of water vapour and on the water content and swelling of wool fibres at various temperatures and humidities is required. Experiments have been commenced at the Sydney Laboratory to collect such data, for they may permit economies to be made at various stages of processing. They will also improve our understanding of the flow of water vapour and heat through fabrics when used as clothing.

9. Yarn Manufacture.

(Wool Textile Research Laboratories.)

After a temporary delay, due to the departure overseas of the officer concerned, work is proceeding at the Geelong Laboratory on the mechanism of drafting in worsted processing. Measurements of the coefficient of friction between a worsted yarn and steel have been made for a range of yarn speeds, and the physical properties, such as surface tension, viscosity, and angle of contact against wool, of the oils to be applied to the wool during processing have also been determined for a wide temperature range.

10. Bleaching and Dyeing.

(Wool Textile Research Laboratories.)

No further work has been undertaken in this field during the past year but it is intended to resume the work shortly at the Geelong Laboratory when a trainee returns from abroad.

11. Chemical Modification of Wool.

(Wool Textile Research Laboratories.)

(*a*) *Application of Resins to Wool.*—Research in this field was developed at the Geelong Laboratory to the industrial stage during the year. Collaboration with industry led to the setting up of a small plant for treatment of half-hose and goods so treated are now on the market. It was found that the most convenient method of treatment was to squeeze the goods mechanically in the smallest possible amount of resin solution followed by tumbling to distribute the resin evenly throughout the material. In this way it was possible to carry out the treatment with a liquor: goods ratio of less than 2 : 1.

Further work is in progress to improve the method of treatment and extend the process to other types of material.

(*b*) *Mothproofing.*—Preliminary experiments at the Geelong Laboratory on a new process for the mothproofing of wool have given encouraging results and the economics and large-scale possibilities are now being explored. Work at the Division of Entomology on the digestion of wool by insects is reported in Chapter IX., Section 4 (*a*).

12. Physical Properties of Fibres.

(Wool Textile Research Laboratories.)

The physical properties of the wool fibre are of considerable importance both in processing and end use, but they have not yet been sufficiently explored for the physical behaviour of a wool fibre to be predicted in all situations.

(*a*) *Mechanical Properties.*—A variety of mechanical forces are applied to fibres while they are being processed, and the usefulness of the finished product often depends on its response to mechanical forces. A thorough investigation of the mechanical properties of the wool fibre has been commenced at the Geelong and Sydney Laboratories, since it will not only provide information concerning the structure of wool but may also show how processes can be modified or improved or even how new products can be devised.

The mechanical behaviour of a wool fibre is complicated. Under wet conditions it can be stretched to 30 per cent. beyond its original length without affecting its capacity to recover from the deformation. Larger extensions can also be imposed without breaking the fibre. The relation between load and extension is not simple because wool behaves partly as an elastic substance and partly as a viscous substance. Particular attention is being paid to creep and relaxation. Under certain constant loads a wool fibre will continue stretching for a long time. This is termed creep. Alternatively, if a wool fibre is stretched suddenly by a fixed amount, the tension in the fibre after stretching will fall continuously. This is termed relaxation. Some progress has now been made in showing the effect of variables such as temperature and stress on the creep of a wool fibre.

Means of investigating elastic constants and internal friction are also being sought. Determinations are also being made of the elastic constants of keratin in the form of ram's horn, by measuring the velocity of transmission of ultrasonic waves.

A sensitive and accurate extensometer is being constructed to enable the load-extension relation of wool fibres to be measured under loads insufficient to remove crimp.

(*b*) *Mathematical Theories of Viscoelasticity.*—This work at the Sydney Laboratory has been carried as far as necessary for present needs, and reports are being prepared.

(*c*) *Supercontraction.*—Under certain steaming and chemical treatments a wool fibre is capable of contracting to 70 per cent. or less of its original length. This is termed supercontraction. An investigation of supercontraction is expected to provide useful information on the structure of the wool fibre and may have applications in processing.

It has now been shown that supercontraction is markedly reduced by the adsorption of extremely small amounts of detergent on the wool. This phenomenon is being studied at the Sydney Laboratory. The work with detergents is being supplemented by the use of dyes since their distribution can be observed in fibre cross sections under the microscope.

(*d*) *Macrostructure.*—No proper study has been undertaken of the macrostructure of the wool fibre under strain, yet such a study is clearly of importance to show how strains imposed on the fibre as a whole are distributed to component parts. Microscopy methods are therefore being developed at the Sydney Laboratory for observations on distorted fibre sections.

(*e*) *X-ray Diffraction.*—Wool shows a different X-ray diffraction pattern when unstretched and stretched, corresponding to α- and β-keratin respectively. The rate at which the transformation takes place would be of considerable assistance in understanding the mechanical properties of wool and it is hoped that the Geiger counter type of X-ray diffraction equipment in use at the Sydney Laboratory will enable the change to be followed closely.

13. PROTEIN STRUCTURE.

(Division of Industrial Chemistry.)

The study of protein structure has been continued by the Chemical Physics Section of the Division. The objects of this work are to increase our knowledge of the structure of proteins, particularly fibrous proteins, to understand their properties and function better, and to study the relation between globular and fibrous proteins in an attempt to elucidate the way in which fibrous proteins are formed *in vivo*.

On the synthetic side, methods of forming the p
linkage have been explored; of particular inter
the use of azides in peptide synthesis. The r
glutamic acid and related compounds in certain pr
has been the subject of some investigation; sinc
possible that pyroglutamic acid is a constitue
collagen and gelatin, experiments on the acylati
this acid to form peptides and the cyclization o
tamic acid residues in lower peptides have been

The structure analysis of DL-aspartic acid
chloride by X-ray methods is nearing completio
a three-dimensional analysis of the structure
crystalline tripeptide, DL-leucylglycylglycine, i
gressing satisfactorily. These and the str
analyses of amino acids described in previous A
Reports have contributed greatly to our understa
of the way in which side chains pack in more co
peptides and proteins.

Electron-microscopical studies of the structure
macromolecular level have been continued. A
ficant contribution to this field has been the c
terization of the molecule of ferritin, a protein
has special merits for electron-microscopical
Sections of biological specimens and of protein c
down to 100 Å in thickness can be cut on a micr
recently constructed in the Section; this will
the range of application of the electron microscop
siderably.

14. WOOL PROTEIN CHEMISTRY.

(Wool Textile Research Laboratories.)

(*a*) *Chemistry of Wool Formation.*—Studies o
synthesis by the laboratory cultivation of the
tissues of foetal lambs have been temporarily c
tinued owing to accommodation changes in the l
tory. The histochemical examination of sectic
sheepskin, however, has been continued at the
bourne Laboratory and a new method has reveal
distribution of an enzyme system in and arour
root at the base of the wool follicle not prev
recognized at this site. The same method has
shown to be more sensitive than those previously
able for demonstrating the distribution of sulpl
groups in the unkeratinized portions of the wool

(*b*) *Amino Acid Composition of Wool.*—Th
perties of wool, like other protein materials, is
determined by the relative proportions of the v
amino acids present. Literature figures for the
acid composition of wool have been determin
various workers using different samples of woo
wool is known to vary slightly in composition, w
in hand at the Melbourne Laboratory to determi
complete amino acid composition on the one s
using sensitive analytical methods which have
recently become available.

(*c*) *Preparation of Wool Dispersions.*—By in
ing wool in alkaline solutions of reducing agents
as thioglycollic acid, more than half of the wool p
is dispersed. Work at the Melbourne Laborato
shown that careful control of the pH and of the
tions of incubation ensures that the degradatio
not proceed beyond the early stages and the pr
are therefore in a suitable state for physical c
terization.

(*d*) *Properties of Wool Dispersions.*—A Hep
osmometer has been constructed and used at the
bourne Laboratory for determination of the
molecular weight of wool dispersions prepared
traction with urea-bisulphite solutions. The
obtained are slightly higher than those previou
ported, and the examination of such extracts
ultracentrifuge in conjunction with measureme
the diffusion coefficient will enable further estima
the molecular weight to be made. Measureme

properties of films of the dispersed wool protein, g a recently constructed low-pressure surface nce, will also provide additional molecular weight . A less sensitive surface balance will be used to ide evidence relating to the interaction of the pro- extracts with other compounds. Infra-red absorp- is being used to characterize films prepared by ng thin layers of the dispersions, especially for the mination of the relative amounts of α- and β- tin present. Moving-boundary electrophoresis of ine thioglycollate extracts of wool has shown the nce of several separate components. The con- ation of one of these increases markedly in relation e other three as the pH of the thioglycollate solu- increases. Information collected by these methods suggest new uses for the dispersed material.

) *Wool Damage in Acid Solution.*—Studies have been completed at the Melbourne Laboratory on reakdown in acid solution of asparagine and of al asparagine peptides of the type likely to occur ool and other proteins. The rate of ammonia ation from both asparagine and asparaginyl ne, for example, resembles that observed during acid decomposition of proteins and is shown to ve both the ionized and unionized forms of the xylic acids. The release of ammonia from glycyl agine and leucyl asparagine is consistent with nternal mechanism of hydrolysis in which only unionized carboxyl groups are involved. In all peptides the peptide bond was more stable to olysis than the amide bond.

15. Fungal Degradation of Textiles.

(Wool Textile Research Laboratories.)

e so-called cellulose C_x enzyme of the mould *rgillus oryzae,* which acts on partly-degraded cellu- has been shown at the Melbourne Laboratory to in at least eight different β-glucosidase com- nts. One of them, which hydrolyses *p*-nitrophenyl- coside, is also capable of transferring a glucose ue to methanol, ethanol, or *n*-butanol. The best ods of fractionating these and other enzyme com- nts in *A. oryzae* culture filtrates, using the tech- e of paper chromatography, have been investigated.

udies of the nutrition of a cellulose-degrading d, *Stachybotrys atra,* have shown that ammonia e used as the source of nitrogen if sugars or acetate lso present in the medium, whereas protein serves source of both nitrogen and carbon. The presence glucosides in the medium is not essential for the uction and purification of those enzymes of *S. atra* h act on unaltered cellulose and can therefore te attack on cotton goods.

XVII. PLANT FIBRES.

1. General.

ntrol of the flax industry by the Commonwealth rnment during the war has resulted in the lishment of a modern and profitable industry. the war, the Flax Research Section was estab- d with laboratories at Highett, Victoria, to meet problems peculiar to the industry in Australia. use of the subsequent extension of the activities of Section to include work on a number of vegetable s in addition to flax, it was later renamed the t Fibre Section.

ant Fibre Section.—The activities of the Section ace a wide field of both fundamental and applied rch extending from agricultural and processing ems to the manufacturing and utilization of plant products. The main work is with flax, the aim to assist in the establishment of a permanent efficient Australian flax industry. Investigations are, however, also being carried out with a number of other vegetable fibres, the production of which in Australia or Australian Territories is being explored at the present time. Chief amongst these are jute, kenaf (and other jute substitutes), ramie, and coir. In addition to chemical, physical, microbiological, and engineering laboratories, the Section has an experimental flax mill complete with commercial processing equipment, and an experimental spinning mill. The scope of the spinning mill has recently been extended by the acquisition of a carding machine. Not the least of the available facilities is an excellent plant fibre reference library. The Section received over 200 trade inquiries during the year, either by letter or by visit, a number of them involving special laboratory work. The Officer-in-charge of the Section continues to serve on the Flax Production Committee, the Central Fibres Committee, and the Papua and New Guinea Fibres Committee. One of the Section's senior officers recently returned from overseas where, in addition to other visits, he spent some time at Sheffield University engaged in microbiological studies.

Work on the fungal degradation of cellulose textiles carried out by the Melbourne Laboratory of the Wool Textile Research Laboratories is reported in Chapter XVI., Section 15.

2. Agricultural Investigations.

(Plant Fibre Section.)

Co-operation is still being provided in agricultural research on a number of fibre plants. The role of the Plant Fibre Section is to extract the fibre from the plant material and evaluate it in terms of yield and quality. Amongst the departments concerned and the projects in which assistance is being provided at the present time are the following:—

Victorian Department of Agriculture.—The development of disease-resisting varieties of flax. (This Department is also conducting a number of fertilizer trials initiated by the Plant Fibre Section to study the effect of the uptake of various minerals on the development of fibre in the flax plant.)

Flax Production Committee (Commonwealth Department of Commerce and Agriculture).—Field trials of certain overseas and the more promising of the locally developed flax varieties.

Waite Agricultural Research Institute.—The breeding of rust-resistant varieties of flax.

Queensland Department of Secondary Industries. —The growing and processing of jute, kenaf, and *Urena lobata.*

Papua and New Guinea Department of Agriculture, Stock, and Fisheries.—The cultivation and processing of kenaf, manila hemp, sisal, and other fibres.

Land Research and Regional Survey Section, C.S.I.R.O.—The cultivation of jute and similar fibres at Katherine and Kimberley.

3. Processing.

(Plant Fibre Section.)

(*a*) *Method of Purchase.*—The present method of purchasing flax according to weight leaves much to be desired, as it is impossible to assess accurately the value of the fibre in the straw until it has been processed. This may not occur for some months or even years. Experiments have been made which demonstrate that crops can be satisfactorily sampled at the time of delivery to the mill and these samples processed immediately to assess the value of the crop. The results from such samples are also of assistance in checking the efficiency of the mill.

(*b*) *Deseeding.*—Considerable progress has been made with the development of a new type of flax-seed winnowing machine which, it is confidently expected, will be much simpler and more efficient than existing equipment.

(*c*) *Water Retting.*—Further work, on a pilot-plant scale, has been completed using the aerated retting technique for treating flax. As reported last year, this method results in considerably more rapid retting than with the normal anaerobic retting and consequently makes possible an increased output from existing retting tanks. One of the flax mills in Victoria is now equipped for aerated retting in its four tanks and the operation of these tanks under the supervision of officers of this Section is about to begin. Experiments on the effect of temperature on the period of retting have been made with various consignments of jute and kenaf. One problem for which no solution has yet been found is the resistance to retting of jute "ribbons". These are the bark ribbons containing the fibre which are sometimes removed from the green plant in order to reduce the volume and weight of material to be handled during subsequent processing.

(*d*) *Scutching and Mechanical Decortication.*—A detailed survey has been made of possible fields for improvements in flax scutching machinery and these fields are now being systematically explored. Already a number of helpful modifications have been discovered. Experiments with the mechanical separation of the fibre from retted stalks both of jute and kenaf have been continued with satisfactory results.

(*e*) *Preparing and Spinning.*—Studies of the technique of preparing and spinning flax, kenaf, and other vegetable fibres have contributed to the available knowledge of these fibres and of their behaviour during manufacture. One of the more important investigations in hand is of the effects of different temperatures and relative humidities on the performance of various fibres during preparing and spinning. The use of Australian timbers in place of overseas timbers for the manufacture of pressing rollers has been successfully demonstrated.

4. MICROBIOLOGICAL INVESTIGATIONS.

(Plant Fibre Section.)

In order to obtain a more complete understanding of the process of water retting and a background of knowledge which may enable improvements to be effected in this process, a detailed study is being made of retting bacteria. Growth and nutritional investigations being carried out include a study of the basal medium required, the effect on growth of incubation temperature and initial pH of the medium, inhibitory substances, and pectin utilization. Incidental studies are concerned with the use of the nephelometer for measuring bacterial growth and with the use of gas production as a basis for obtaining growth curves for retting bacteria.

5. CHEMICAL INVESTIGATIONS.

(Plant Fibre Section.)

Analyses of various types of flax and other fibres have been continued to define further the constitution of the fibre and to determine the relationship between fibre quality and chemical composition. Particular attention has been given to the effect of treatments with various concentrations of sodium hydroxide. This is the basis of the "boiling" treatment to which practically all flax yarn is subjected. Modifications have been made to the method used for the determinat of lignin in fibre; it is considered that a more accu estimation is now possible. An investigation has b commenced to determine the effect of various proc ing factors on the cuprammonium fluidity of fibre.

6. PHYSICAL INVESTIGATIONS.

(Plant Fibre Section.)

Anatomical investigations have been extended f flax to jute, kenaf, and roselle. Australian-gr material is being compared with that from over and, in particular, a study is being made of relat ships between anatomical characters and fibre qua Determinations have been carried out of the "k efficiency" of yarns of jute and kenaf. This is strength of a knotted yarn expressed as a percentag the strength without a knot. With each fibre the k efficiency is only about 60 per cent. The resistanc yarns of the same two fibres to fungal attack has been studied. Both soil-burial tests and acceler mildew infection tests have been used. Further in tigations have been commenced of the relations between moisture regain and the breaking stre of canvases of Australian manufacture. An exam tion is being made of the use of an imported level tester for evaluating the uniformity of flax and o plant fibre yarns.

XVIII. INDUSTRIAL CHEMISTRY.

1. GENERAL.

The Division of Industrial Chemistry repres the major concentration of chemical research wi the Organization, although much chemical work undertaken in other Divisions and Sections.

This Division was formed (*a*) to promote gre technical efficiency in established industries, (*b*) stimulate the establishment of new industries, (*c* encourage the use of raw materials of Austra origin, (*d*) to seek substitutes for imported mater and (*e*) to find uses for by-products not utilized.

In addition to its basic chemical work, the m research activities within the Division deal mineral utilization, cement, ceramics and refracto organic chemicals, wool, and brown coal.

The Division's activities on wool wax and pro structure are described in Chapter XVI., Section and 13 respectively; work on the flotation of mine in Chapter XIX., Section 5; and work on the util tion of brown coal in Chapter XX., Section 9.

Division of Industrial Chemistry.—In addition to staff located in Melbourne, officers work in other St on projects that were enumerated in the 1951-52 Rep The Foundry Sands Section is housed in the Metallu Department of the Melbourne Technical Coll The Organic Chemistry Section has for many y been indebted to the Organic Chemistry Departm of the University of Melbourne for accommodation alkaloids investigations and microanalysis. The mi analytical laboratory has been placed on a more se basis. While the major responsibility for it r with the Division, it is receiving financial suppor the extent of £500 for the year 1953 from the Natio Health and Medical Research Council; it has us guarantees from Monsanto Chemicals (Aust.) I Imperial Chemical Industries of Australia and N Zealand Ltd., and Australian Paper Manufactu Ltd., and more extensive guaranteed patronage f the Universities of Melbourne, Sydney, and Adela In addition, the University of Melbourne has un taken, on a long-term basis, to continue to house Section.

iaison with industry and with educational institus has been very cordially maintained. There have ı numerous formal visits of inspection by repreatives of industries and associations which may to extensive work within the Division's laboraes. Thus, one firm had a research officer seconded he Division for a year for work on olein, with a / to developing marketable products for this erial. Again, an agreement has just been reached ı Mount Lyell and Mount Morgan mining comies under which the Division will conduct research ı large pilot-plant scale on a new method of treatcopper concentrates. The companies will provide ost the whole of the money needed, and the greater of the personnel required, about ten in all. The cess Equipment Laboratory continues to render tantial assistance to a wide range of industries the Foundry Sands Laboratory to the whole stry in Australia.

fficers of the Division deliver many lectures to ntific and technical societies. One was invited by Chemical Institute and the Universities of New and to give a series of addresses in that country. ee officers have accepted invitations to lecture in ope and North America.

he head of the Cement and Ceramics Section, Dr. R. Alderman, resigned to occupy the Chair of logy at the University of Adelaide and has been ceeded by Mr. A. J. Gaskin, of the Geology artment of the University of Melbourne.

number of guest workers in various fields of rech have been accommodated in the Division, and ral requests for scientists from other institutions vork in the Division have been reluctantly refused ng to shortage of laboratory space.

he following description of the activities of the ision focuses attention on the work of the scientific technical officers. The essential part played by clerical and stores staff and by the workshops staff ecorded with appreciation.

2. MINERALS UTILIZATION.

(Division of Industrial Chemistry.)

he utilization of minerals and products derived n them offers considerable scope for chemical rerch. The procedures necessary to modify the perties of the mineral to meet the requirements of ticular industries are very diverse; in some ances little or no processing is required but the majority of cases drastic changes by mical means are necessary. It is by such mical processing that the potential value of nineral can be realized through its derivatives it is through the production of a wider range of ivatives and their industrial application that elopments in this field may be expected to occur. current programme is based on some of the less mon metals, minerals, and their derivatives and es partly from the relative abundance of certain hese minerals in Australia and the increasing indusl attention being devoted to them. It is also, in t, dictated by the coexistence of a variety of chemiy similar metals, or elements, in several of the erals under consideration. The separation of these ely associated elements is usually a necessary pree to further studies on their individual utilization l the devising of improved methods of separation omes a major part of the investigation where, as quently happens, the known methods of separation imperfect. The various research projects in the rent programme, which are briefly reviewed hereler, provide several examples of this sequence.

(*a*) *Lanthanon and Thorium Chemistry.*—The chemistry of the lanthanons, or rare earths, and of the frequently associated element thorium, has occupied the attention of the Section for a considerable time past. The practical difficulties associated with the separation of most of the lanthanons from the complex mixtures in which they occur have, until recently, strictly limited any consideration of devising industrial uses for certain of them. The recent development of improved separation techniques in overseas laboratories has been chiefly related to studies on the fission products of uranium and this Section's current work has been directed towards the development and adaptation of such of these modern methods as may be applicable to the problems of industrial separation of the lanthanons and related elements from mineral sources. The natural occurrences of this large group of closely associated chemical elements are very diverse in Australia, and for the most part the recovery of the minerals, or their chemical derivatives, is subsidiary to the concentration or chemical processing of other minerals. Thus monazite, the main source of the cerium group of lanthanons and thorium, is recovered in the mechanical concentration of titanium and zirconium minerals from the beach sands of eastern Australia and occurs also in many alluvial tin drifts. Minerals of the fergusonite type, in which the yttrium group of lanthanons predominates, are known to occur with tin ore in Western Australia and elsewhere. Certain Australian uranium ores also contain the lanthanon suite of elements as subsidiary components. These three sources have been availed of in the current work on separation techniques which have been mostly based on the formation of complexes with various organic reagents followed by ion exchange. One aspect of this work has been the subject of a patent application as a new method of lanthanon separation, and several publications dealing with other phases of this work have been prepared. Preliminary investigations into new sources of lanthanons and related elements have involved examinations of a variety of Australian tungsten ores and associated gangue minerals with the result that epidote from the scheelite deposit at King Island has been shown to contain lanthanons, although the scheelite itself does not. The occurrence of appreciable amounts of the rare element scandium in davidite concentrates from South Australia has been confirmed and small amounts of scandium compounds have been isolated from this source for the first time. This work has indicated that the published chemistry of scandium in complex mixtures needs considerable revision and to this end the investigation will be continued. Fundamental work on the carbides and iodides of thorium relating to the thermal deposition of the pure metal was continued. Work is also proceeding on the fluorides of cerium and their possible use as fluorinating agents.

(*b*) *Titanium and Zirconium Chemistry.*—Investigations on the preparation and properties of titanium nitride have been continued. This material, which is derived from rutile via titanium tetrachloride, shows promise for the preparation of various industrial hard "metal" compacts analogous to those composed of tungsten carbide. The many variables involved in the composition, melting, bonding, and sintering of the nitride have necessitated a very extensive series of test pieces being made and compared for performance. The possibilities of using titanium nitride as a component of special types of electrodes and as an ingredient of the composite ceramic-metal compositions known as cermets have also been examined.

A series of investigations on the properties and possible uses of other binary compounds of titanium was commenced. The electrical properties of sintered polycrystalline compacts of partially reduced titanium oxide were studied in conjunction with those of sintered titanium oxide rendered photosensitive by introduced impurities.

Work on the chemical separation of zirconium from associated hafnium was continued with satisfactory results. A new process devised for this separation has proved effective in laboratory-scale tests and the equipment necessary for pound-scale tests was designed and assembled.

(*c*) *Graphite Investigations.*—The work on lamellar compounds of graphite has been continued and the capacity of graphite to form molecular compounds by the intercalation of various foreign substances in the interplanar spaces of the crystal lattice has been investigated in some detail. Recognition of criteria which determine the high degree of selectivity shown by graphite in forming this type of compound has resulted in the discovery of a large number of new compounds. The conditions under which such compounds are formed and subsequently decomposed suggest that important applications of the principle may be devised to effect various separations of industrial importance. The theoretical and applied aspects of this project have been considered concurrently and are being extended.

(*d*) *Chemical Crystallography of Minerals.*—The chemical crystallography of minerals possessing structural defects in the lattice of the crystal has been continued and the crystal structures of the two manganese minerals psilomelane and chalcophanite have been determined by Fourier methods of X-ray analysis. The synthesis by means of the Verneuil, or flame fusion process, of single crystals of various inorganic compounds with defect structures predicted from X-ray studies, has met with initial success. The products, which have potentially useful electrical properties, are being examined.

(*e*) *Germanium Survey.*—Wide interest in the use of germanium for transistors and similar electrical devices has suggested the desirability of a survey of Australian sources of this uncommon element. It is known that certain Australian coals and their derived flue ducts, like those reported elsewhere, contain small but significant amounts of germanium. The survey has been planned to include not only coals but a number of minerals and metallurgical by-products. As yet this work is in the preliminary stages.

(*f*) *Uranium Ores.*—Work on the extraction of uranium from the davidite ore from Radium Hill, South Australia, was concluded and four of the Section's staff joined the research staff of the South Australian Department of Mines to continue investigations on the treatment of this ore and related problems. Current work on davidite ore in this laboratory has been restricted to devising methods for the isolation of scandium and recovery of lanthanons from by-products obtained in the treatment of the ore.

Investigations were continued on the treatment of uranium ore from Rum Jungle, in the Northern Territory, with satisfactory results. This work has been done in collaboration with Consolidated Zinc Pty. Ltd. who have supplied ore samples from the mine, and also with the South Australian Department of Mines and the Melbourne University ore-dressing laboratory.

3. CEMENT AND CERAMICS.

(Division of Industrial Chemistry.)

Work has continued on the study of portland cement and pozzolanic cements, on ceramics including refractories, on the survey of Australian resources of ceramic clays, and on the structure and properties of the clay minerals.

As in the past, assistance has been given to Govern ment Departments and instrumentalities by testi various materials proposed for use in large concre structures. As a result of this work unsuitab materials have been rejected and replaced by othe which met the necessary standards. Samples of co crete from damaged or disintegrating concrete stru tures have been examined, causes of failure determine damage assessed, and remedial measures suggeste Though it has not been possible to undertake tes except in special circumstances, assistance has be given in several instances by providing details of, a instruction in, testing procedures and the interpretati of the results. Assistance has also been given to vario industries engaged in the manufacture of ceme ceramics, and refractories and to several users of the materials. Both practical and financial assistance h been received from the Cement and Concrete Associ tion of Australia and from the National G Association.

(*a*) *Cement and Concrete.*—The research programm covers a number of factors that influence the setti and hardening of portland cement and the durabili of concrete. Various reactions that take place duri the setting of portland cement are being studied, a they are being correlated with actual setting a strength development. This includes the action accelerators and retarders, and the factors that gi rise to "false" setting and "flash" setting. In ad tion, work on the hydration of cement minerals and t development of strength was recently commenced. A these investigations are directed to obtaining inform tion which could lead to the development of strong more rapidly acting cements and more durable concre

Various aspects of the disintegration of concrete a being studied, with particular reference to the types disintegration brought about by sulphates a chlorides, by frost, salt scaling, and magnesia hydrati

The investigation of alkali-aggregate reaction p viously reported has led to further work to determi how crack patterns develop and how a concrete stru ture disintegrates. It has been demonstrated th cracked mortar specimens can be so treated that th tensile strengths are increased and their permeabilit to air and water are decreased. It has been observ that cracked mortar specimens, when subjected to t influence of various salt solutions, expand in a mark fashion as a result of the widening and propagation the cracks.

An investigation of the mechanisms of shrinkage a the development of shrinkage cracks in cement pa and mortar specimens has commenced. This shou ultimately assist in the design of concrete mixes a concrete structures that do not undergo excess shrinkage.

Studies on the mechanism of air-entrainment cement and sand pastes have been continued, and ha provided useful data on the effect of the physical a chemical environment in a cement paste on t properties of surface-active agents and their effecti ness in promoting the entrainment of small air bubb

A study of the behaviour of certain finely grou siliceous materials known as pozzolanas, and t development of strength of blended portland-pozzola cements in mortar has been continued. These pozzola materials have considerable value in improving t durability of concrete under certain conditions, and t use in mass concrete such as in gravity dams.

Although much of the mineralogical work on ceme clinker has been suspended, the study of the separati of "glass" from portland cement clinker at high te peratures and determination of its composition h tinued. Further studies are also being made of the ion of this glass on clinkering and the formation of apounds in the clinker.

b) *Cement-kiln Refractories.*—The work in this l, which is concerned with the investigation of ors which affect the life of kiln linings, includes udy of the attack by potash volatilized from the feed on high alumina and chrome-magnesite bricks. as been shown that the interstitial bonding material ttacked and that its physical properties are altered. a result it has been possible to indicate how this n of attack on certain aluminous bricks may be imized.

ecause of the extensive overseas use of bauxite as aw material for high-alumina refractories, the ibility of making suitable bricks from Gippsland xite is being investigated. Though the amounts of ain impurities are higher than is considered desir-, bricks have been made from it and their properties being evaluated.

he influence of purely mechanical stresses on the of refractory bricks is also being investigated. A y of the changes of cross section taking place in kiln shell during rotation has indicated the nature ne disruptive forces and how they may be minimized placing stiffening rings around the shell.

:) *Gas-works Refractories.*—The investigation of ors limiting the durability of gas-works refractories er conditions of heavy steaming has been continued. er these conditions the life of the retort is reduced n increased tendency to slagging and cracking. An mpt is being made to diagnose the cause by repro-ng these deleterious effects in the laboratory under litions which simulate those in a retort during ation.

l) *Survey of Clay Resources.*—Work on the mic and refractory clays of Western Australia has been completed and will be published by the tern Australian Department of Mines. A similar ey of clays from Queensland is being made in boration with the Queensland Geological Survey. ddition samples obtained from other areas, which ear likely to have industrial uses, are being nined.

the course of this work the use of adsorption of ve by clays as a rapid indicator of their cation-ange capacities and dry strengths was studied. required an examination of the factors affecting letermination of all three, and improved procedures developed. Using these methods a good correla- was found and the dye-adsorption technique is g simplified to make it suitable for the rapid acterization of clays for field surveys and for the ratory control of raw materials in ceramic industry.

) *Clay Mineralogy.*—In ceramics, agriculture, and r industries the behaviour of clay-water systems is ajor importance. In order to control or alter the erties of such systems effectively, it is necessary that structural make-up of the clay minerals should be understood. Much interest centres around the titution of montmorillonite, the main constituent he bentonites, fuller's earth, &c. It is a highly tive clay mineral, but because of the fine state of ivision in which it occurs it does not lend itself to cture analysis by existing physical methods. ever, the mineral vermiculite, which is a con-ent of certain soil-clays and also occurs in nature akes large enough to be examined by single-crystal y techniques, appears to be so similar in structure properties to montmorillonite as to suggest that its y, important in itself, should also provide informa- about montmorillonite.

The structure analysis of vermiculite, mentioned in last year's Report, has now been completed and an account of the work is in the press. No comparable study of any clay mineral has been published. Clear evidence has been obtained of the atomic structure of the mineral, together with the configuration of the associated water films and exchangeable cations. Considerable light has been thrown on the mechanism by which exchangeable cations are held at the active surfaces of clay particles. The behaviour of the cations on hydration seem to play an important role. The extent to which the results obtained can be used in explaining the properties of montmorillonite is under investigation by chemical methods.

In the casting of ceramic bodies kaolinitic clay is customarily deflocculated by the addition of alkali—usually a mixture of sodium carbonate and sodium silicate. This confers upon the slip the properties of both high density and fluidity. Control of the degree of deflocculation and thus of the properties of the casting slip are of importance in the maintenance of reproducibly high standards in pottery and porcelain manufacture. The mechanism of deflocculation in pure kaolinite suspensions has been the subject of study at Rothamsted Experiment Station, England, by an officer of the Section. From it has emerged a new interpretation of the process, which should be of value in all processes in which deflocculation plays a part and in the prediction of the colloidal behaviour of mixed clay minerals. In addition, it has established a new method for the estimation of the specific surface of a kaolin.

(*f*) *Silica for Bricks.*—Efforts are being made to discover sources of silica in this country suitable for the manufacture of bricks comparable in quality with the South African "silcrete" bricks. From rocks of the "silcrete" type silica bricks can be made which have a low porosity and high degree of conversion to crystobalite and tridymite. It is to these stable high-temperature forms of silica that these bricks owe their low after-expansion which is so desirable in refractories used in gas retorts, open-hearth steel furnace roofs, and glass-tank crowns. A number of easily accessible deposits of silica were examined but they were not superior in quality to those at present used in local manufacture, owing largely to the relatively large size of the crystals of which the rock is composed. The survey is now being extended to regions where microcrystalline forms of silica are known to occur but have not previously been tested with a view to the manufacture of silica bricks.

(*g*) *Whiteware and Related Investigations.*—A study of porosity in whiteware bodies which has just been published shows how porosity may be influenced, inadvertently or deliberately, by the method of processing. Another recent publication shows the effect of extrusion and other processes on the microstructure of clay. Re-orientation of the particles and the formation of slip planes alter the structure of an extruded column of clay and affect its tendency to undergo cracking and lamination. Although extruders are used throughout the ceramic industries, there has been little understanding of the behaviour of materials subsequent to extrusion or of methods of controlling it. Further studies are relating these results to differential drying shrinkage, strain, and cracking, which are problems of general interest to the ceramic industries. There is evidence that the formation of a vesicular structure known as "bloating" in ceramic bodies is aggravated if the feldspar used as a flux has previously undergone appreciable decomposition by weathering. Work is continuing on the mechanism of bloating and the melting of feldspathic fluxes.

(*h*) *Special Ceramics.*—Attention is being given to special oxide refractories, and to the ceramic-metal combinations known as cermets, which have many special uses, such as for high-temperature jets and turbine blades.

(*i*) *Other Investigations.*—Assistance has been given in response to many inquiries by both potential and actual manufacturers on the availability of ceramic materials, in Australia, and on the production of ceramic bodies from these materials, particularly in the production of articles of a similar kind and standard to some at present imported. Other inquiries have led to a diagnosis in the laboratory or on the plant of faults arising during manufacture. In addition, the Section has produced a number of special ceramics for use in investigations by other Sections of the Division.

(*j*) *Adelaide Ceramics Laboratory.*—This laboratory, which is operated in conjunction with the South Australian School of Mines and Industries, provides for the ceramic industry an advisory service which has been much in demand. In addition to this work, surveys of a number of deposits of clays and shales have been made, and detailed laboratory tests have shown how they may best be used, alone or blended, for brick-making and other purposes. This work will be reported in the *Mining Review* published by the South Australian Department of Mines.

4. Foundry Sands.

(Division of Industrial Chemistry.)

The metal founding industry requires supplies of a range of different grades of sand for production of moulds and cores, the types of sand employed depending on the nature of the castings required. Changes in moulding practice bring demands for new types of sand. Much of the work has been devoted to maintaining an up-to-date catalogue of the known sand deposits adjacent to Australia's principal cities and towns in which foundries are situated. During the year numerous additional deposits of sand have been sampled and subjected to standard tests. The Victorian Department of Mines has collected many samples in a search for new deposits and these have been tested for suitability as foundry sands.

The recently developed foundry technique of shell moulding requires a sand with unusual physical properties. Surveys have been made of two deposits of sand considered suitable for production of shell moulds, and samples have been subjected to standard tests and employed in experimental moulding operations. The advisory service provided by the Section in general foundry problems has involved several minor laboratory investigations, including small-scale casting operations. Work has been continued on production of synthetic moulding sands using Australian bentonitic clays.

5. Physical Chemistry.

(Division of Industrial Chemistry.)

This research programme comprises physico-chemical studies, both fundamental and applied, of the properties of surfaces, the properties of fluids, and the transfer of materials from one phase to another. Fundamental studies include liquid-vapour equilibria of value in distillation problems; the properties and reactions of fluids under high pressure, providing data of value in predicting the properties of liquid and gaseous systems; and the mass transfer of materials across liquid interfaces. On the applied side, set against a background of fundamental surface chemistry, are the selective flotation of minerals, the recovery of wool wax, dropwise condensation in condensers, the control of evaporation by surface films, continuous methods of separation, the principles governing the effectiveness of fillers rubber.

(*a*) *Properties of Liquids.*—The wide uses of ind trial chemical processes involving liquids, such distillation and solvent extraction, make an understa ing of the thermodynamic properties of liquids solutions of fundamental importance to the chemi engineer. The combined experimental and theoreti study of this problem has therefore been continu The liquid-vapour equilibria and heats of mixing of system ethyl alcohol + carbon tetrachloride have b measured and the behaviour of the mixture has b explained theoretically.

A convenient and accurate method has also b developed for the calculation of the composition of vapour in equilibrium with a solution from the t vapour pressure. A theory previously developed predicting the properties of solutions containing a hols has been extended to cover solutions of a numbe other "associated" liquids, many of which are industrial importance. A further theoretical adva has explained some of the properties of two-phase liq systems, particularly those which become complet miscible at both high and low temperatures.

(*b*) *Chemical and Physical Effects of High Pressu*

The industrial importance of the accelerating fluence of high pressures on some chemical reaction now well established. But the amount of quantitat work which has been done on even simple chemi reactions is surprisingly small. A systematic stu has therefore been initiated at the Division's H Pressure Laboratory in Sydney of both theoretical experimental aspects of the chemical effects of pressu This has established the underlying cause of many the reported effects of pressure. Measurements continuing on the displacement of equilibria and changes in reaction rates brought about by pressu up to 12,000 atm.

Further measurements have been made of pressure-volume-temperature relationships of gases both low and high pressures. The volumetric behavi of hydrogen and deuterium at low temperatures has be shown, both by theory and experiment, to be subject large quantum effects not found in heavier gases.

The second and third virial coefficients (indicative the departure of actual gases from the behaviour of ideal gas) of a number of hydrocarbon gases have be computed from their published compressibilities an molecular theory of these coefficients for polyato molecules in general is being worked out. This the should be useful in predicting many of the propert under high compression of gases with comp molecules.

(*c*) *Continuous Adsorption Processes.*—The work the purification of antibiotics by two fractional adso tion processes has been concluded and the results of are in the press. These processes are being followed by a local manufacturer. Some of the techniq devised for this work have been used in a continu ion-exchange process with the ultimate aim of apply them in large-scale metallurgical processes. Spec importance has been attached to the development o continuous process. Previous attempts elsewhere h failed because of the use of vertical towers; these ca difficulties in moving a bed of ion-exchange resin i uniform manner countercurrently to a flow of liqu Difficulties are also encountered in removing re uniformly over the whole cross-sectional area, and avoiding abrasion of the resin. These disadvanta have been overcome by adapting a mineral jig, and process developed provides ease of control and econo of resin, and it may be used for either stripping fractionation. A bed of ion-exchange resin retained reen in a long narrow trough is maintained in a turbulent semi-fluid condition by a simple pulsating ow which causes it to move linearly along the gh. Initially water softening was chosen as a ess for study because of its experimental advan- s. Calcium ions are continuously removed from water in a softening unit and the calcium resin is ierated (after removing excess water on a filter) countercurrent flow of brine in a separate unit. resin is then rinsed, de-watered, and returned to softener. This process, which is being operated pilot scale, appears likely to be adaptable to other ations, and a patent application has been lodged.

) *Mass Transfer.*—In connexion with some work h is being done on the separation of the com- nts of wool wax by solvent extraction, a study is g made of the effect of hydrodynamics in mass sfer of materials from one liquid phase to another. c information is being sought on the factors which rn the rate of extraction of a dissolved substance he second liquid phase, in particular the kinds extent of motion in the phases and, if one phase is ent as droplets, the nature of movements within . This information is being obtained by studying lets in a hydraulic tunnel.

) *Surface Films.*—A study has been made of the ical and chemical properties of spread mono- ecular layers of compounds similar to those present vool wax. It has been shown that the monolayer niques may be used advantageously for deter- ng the general architecture of molecules contain- between 12 and 40 carbon atoms, and for rmining the positions within the molecule of chemi- reactive groups. It is considered that the tech- es will be particularly useful in determining the cture of materials available only in small amounts, only 0.0001 g. is required.

he structure of eburicoic acid, a triterpene occurring rtain wood fungi, has been determined and shown e similar to lanosterol, a constituent of wool wax. configurations of a number of other compounds also been determined.

ttempts have been made to reduce evaporation from water surfaces, a problem of some importance in s of low rainfall, by covering the surface with luble surface films. A number of films were loped and found to be unaffected by wind and . Nevertheless these films failed generally to ce the natural rate of evaporation of water. As a equence the long-held view that the failure of ace films results from damage has been abandoned, the lack of success has been traced to compensating ts resulting from heating of the water by the sun. rnative methods of water conservation are being nined.

) *Wool Wax Recovery.*—The flotation method of vering wool wax from scour liquors which was sed and developed in this Section has been modified roduce a wax superior to that usually obtained by r methods. It has aroused wide interest in Aus- ia and overseas and has recently been brought into mercial use. The process is described in Chapter I., Section 6.

g) *Flotation of Cassiterite.*—Work on the flotation assiterite from the ore from Maranboy, Northern ritory, was suspended while still in its preliminary es in order to complete the development of the ess for recovering wool wax from scour liquors. k on this ore has now been resumed and the results e been sufficiently encouraging to justify an nsive investigation.

h) *Condensation of Steam.*—The greatly improved transfer coefficient of a condenser surface on which lensation occurs as droplets rather than a film has been further investigated by the use of an experimental boiler and condenser. A number of substances has been used to render the surface of the condenser hydrophobic, but so far their effect in causing vapours to condense in a drop-wise fashion has been only temporary. The range of surface treatments is being extended. Concurrently, a study is being made of the fundamental mechanism and kinetics of the process. A quartz microbalance is being made for the measurement of the adsorption of water on hydrophobic surfaces and is nearly complete. It will be of general value for adsorption studies, and for the determination of surface areas of powders.

(i) *Heterogeneous Catalysis.*—Because of the widespread use of catalysts to accelerate reactions in the manufacture of chemicals, an understanding of their functions is of considerable importance in achieving maximum yields at low temperatures. Work was concluded during the year on the rate of transport of gases and their reaction in the pores of two industrially important catalysts, thoria and alumina, and the way these rates are affected by pressure, temperature, and size of pores. This work is described in a series of papers now in the press.

(j) *Reinforcing and Extending Fillers for Rubber.*—At present, reinforcing fillers for rubber, such as the carbon blacks and the so-called white fillers (silica, alumina, and clays), are imported, and it is of both strategic and economic importance to determine whether local raw materials can be used successfully for this purpose. The mechanism of reinforcement is not fully understood and an attempt is being made to determine what factors control it, and from this to develop laboratory methods which can be used to predict the reinforcing activity of a filler without recourse to the time-consuming process of compounding and testing samples of the filled rubbers. If simple techniques could be developed it would greatly facilitate a survey of Australian raw materials. Recent tests suggest that some Australian clay minerals may prove suitable as substitutes for some imported fillers.

6. Chemical Physics.

(Division of Industrial Chemistry.)

The main investigations in this field are: (i) the chemistry and physics of defect solids, basic to the whole of chemical industry; (ii) the structure and energetics of molecules, a problem of major importance in both primary and secondary industry; (iii) the structure of proteins; (iv) the development of specialized instruments and techniques. The Section has continued to give specialist service to industry, university science departments, research institutions, and other branches of this Organization. No fewer than 37 projects, some of a long-term nature, have been undertaken during the past year. Most of the techniques first introduced into the country by the Section are now well established in scientific centres throughout the Commonwealth.

One of Australia's most pressing needs is a scientific instrument industry adequate to meet the increasing demands of national defence, chemical industry, and scientific investigation. Details of instruments developed in the Section and in other parts of the Division have been in demand all over the world; in one instance, in which an instrument based on a new principle was patented, licences have been sought by leading manufacturers of spectroscopic instruments in both the United Kingdom and the United States of America. The Division's experience in instrument development could well form a very significant part of the technical background essential for adequate expansion of instrument manufacture in Australia.

(*a*) *Protein Structure Studies.*—Investigations of the structure of proteins, particularly fibrous proteins, such as wool, which are essential to an understanding of their properties, and of biological function, have been continued. This work, which includes the synthesis of peptides, structure analysis by X-ray methods, and electron-microscopical studies at the macro-molecular level, is described in Chapter XVI., Section 13.

(*b*) *Chemical Physics of the Solid State.*—Imperfections and defects in solids are now widely recognized as the operative factors in chemical reactions in solids, in the operation of catalysts, and in many important physical properties. The aim of this work is to obtain information on the nature and properties of defects in solid systems, so that their chemical properties may be interpreted.

The apparatus for obtaining precise optical constants of evaporated films of insulating solids has been completed and data have been obtained for zinc sulphide films over the visible and quartz ultraviolet spectral regions. Techniques for obtaining reproducible evaporated films and for the measurement of their thickness by multiple-beam interferometry have been established. By studying the low-temperature photoconductivity simultaneously it is hoped to obtain an unequivocal energy level diagram for a particular solid. The luminescent properties, from which the nature and probability of electronic transitions in these solids may be determined, are being investigated by periodic excitation methods.

Simple reactions, such as the oxidation of metals, are being studied to establish their mechanisms and the role of defects in the product oxide phase. An apparatus, incorporating a number of novel features, has been developed for this purpose. It is planned to follow this work with investigations designed to establish the nature and behaviour of the operative defect in each oxide phase.

Electron diffraction studies on solids containing structural imperfections, such as dislocations, have allowed the nature of the dislocation and its relationship to the crystal symmetry to be established in specific instances. Some anomalous results in electron diffraction and the growth and habit of certain crystals (for example, copper oxide and zinc oxide formed under certain conditions) have been explained. The structural implications of impurity defects have been deduced for γ-alumina containing small amounts of nickel, and gold containing small amounts of dissolved oxygen.

(*c*) *Molecular Structure Studies.*—Both experimental and theoretical methods have been used in elucidating the structures of molecules and evaluating the mechanisms and energies associated with molecular processes. Data of these kinds are in continual demand for the solution of problems of applied chemistry. The development of new and more powerful methods has played an important part in this work; this is discussed in more detail in Section 6 (*d*) below.

(i) *Structure Analysis by X-ray Diffraction Methods.*—Apart from the analyses which form part of the protein programme, the X-ray group has been engaged in two major structural studies. The structure of the physiologically interesting alkaloid, cryptopleurine, is being analysed by the heavy-atom method, since chemical methods have failed to give definite information on the structure of the molecule. The structure analysis of the clay mineral vermiculite, undertaken in collaboration with the Cement and Ceramics Section, has been completed.

(ii) *Structure Analysis by Electron Diffraction Methods.*—Single-crystal structure analysis by electron diffraction methods was pioneered in this Section. The specific advantages over the X-ray method, which it is to some extent complementary, are t extremely small crystals may be studied and that lighter atoms scatter electrons relatively more efficien Experimental and interpretive techniques have b refined.

Hydrogen-bond configurations have been dem strated directly in Fourier projections of the la structure of boric acid; some unusual features of t configuration, neither known nor suspected, were fou

From the fine structure of reflections from sn crystals of regular habit the structure factors for th reflections may be deduced. The possibility of coll ing data in this way for subsequent structure analy has been examined and a Fourier section of the M structure has been computed; this represents the f structure analysis carried through by Fourier meth without reference to intensities of reflections. T potentialities of this method are consideral problems associated with its application to unkno structures are being examined.

(iii) *Spectroscopic Studies of Molecular Inter tions.*—The absorption spectra of simple compounds solution have been studied to obtain data on the nat and magnitude of interactions between molecules solutions. The assignment of the electronic ene states of iodine has been revised and potential ene curves have been computed from the available b spectroscopic data. This is a necessary prelimin to a complete interpretation of iodine solution spec

An officer of the Section, located in the Chemis Department, University of Western Australia, continued to work in collaboration with Professor N Bayliss on solution spectra in the vacuum ultravi region.

(iv) *Molecular Ionization Potentials and B Energies.*—Considerable progress has been made in work directed towards the measurement of dissociat energies of bonds in molecules, of importance chemistry, and the study of low-pressure ionizat processes, of value, for example, in the physics of upper atmosphere.

A new method of making these measurements, cussed more fully in Section 6 (*d*) below, has b devised. A completely unequivocal solution to problem of interpreting ionization efficiency data resulted; this is the first step in using these data the deduction of reliable ionization potentials and b dissociation energies.

(v) *Mechanism of Molecular Decomposition.*— of the basic problems of chemical decomposition r tions is the molecular mechanism by which it occ It is generally agreed that the initial step in ph chemical, thermal, or radiochemical decompositions the gaseous phase may be either the direct product of free radicals or an intramolecular rearrangem The mass spectrometer has been used as an analyt tool in the study of the photolysis of ketones. I found that intramolecular rearrangement in such p cesses involves migration of a hydrogen attached t γ-carbon atom to an α-carbon atom and rupture the α-β carbon bond, whereas free radical decomp tions occur in molecules for which this is not poss (e.g. *iso*propyl methyl ketone).

(vi) *Theoretical Studies.*—The calculation molecular energies by existing methods is restricted complexity to the simplest systems. A new meth based on an electrostatic approximation, has b developed. It can be used to investigate molecules considerable complexity and the calculations may made with less labour and greater accuracy.

(*d*) *Development of Chemico-physical Techniques.*
The development of new techniques and the improve-
nt of existing instruments and techniques is essen-
l to the Section's programme of work. Scientific
ogress is often associated with advances in technique;
is this fact which has prompted close attention to
hnique and instrumentation in the Section.

(i) *Electron Microscopy.*—A microtome for cutting
tions of biological specimens thin enough for
ctron-microscopical examination has been con-
ucted. This problem has received a great deal of
ention in the last ten years, but only recently have
l advances been made. This microtome has proved
pable of cutting sections of protein crystals down
one molecule in thickness.

Artefact detail is frequently encountered in electron
crographs of crystalline substances. These are
ially associated with electron reflection and inter-
ence. One such artefact, consisting of fringes of
acing 20-200 Å over large areas of the surfaces of
nellar crystals, has been investigated in an attempt
establish its origin.

Acute shortage of laboratory space has delayed
velopment of an electron microscope incorporating
vel design features and electron-optical principles.

(ii) *Electron Diffraction.*—A direct and rapid
thod for the measurement of the intensities of
fracted electron beams by purely electronic means is
ng developed. The deficiencies of photographic
thods may be circumvented if the method proves
be as successful as preliminary trials indicate.

A new electron diffraction camera, in which small
ystals giving a diffraction pattern may be observed
ctron-microscopically, is almost complete. This
trument has been designed to allow maximum
ssible information on the structure and habit of very
all crystals to be obtained.

(iii) *X-ray Diffraction.*—The high-temperature
aptor for powder diffraction studies has been com-
ted and used successfully. Adaptation to single-
ystal specimens is under consideration.

An X-ray goniometer for automatic recording of
gle-crystal reflection intensities has been designed
d its construction is in progress.

(iv) *Spectroscopy.*—A novel approach to the spectro-
emical estimation of elements, involving atomic
sorption rather than emission, is being developed.
periments have proceeded far enough to establish
superiority of this approach over conventional emis-
n methods in sensitivity, reproducibility, and sim-
city. The technique is expected to have wide applica-
n.

The multiple-pass principle, used so successfully in
ra-red spectrometers, has been applied to monochro-
tors for use in the visible and ultraviolet employing
otomultiplier detectors. The resolution attainable
s found to be limited not by the optical resolution of
monochromator but by the noise originating in the
otomultiplier, proportional to the total radiation
hopped and unchopped) falling on the detector. A
ovisional patent specification has been lodged describ-
a method of circumventing this difficulty. The
orporation of the multiple-pass principle in a double-
am spectrometer is proceeding.

(v) *Mass Spectroscopy.*—Accurate ionization effici-
cy data are required for estimation of bond dissocia-
n energies and ionization energies. An instrument
ich produces and displays the first and second deriva-
es of ionization efficiency curves has been constructed
use with the mass spectrometer. The electrical output signals, corresponding to values of these derivatives at discrete electron bombardment energies, are converted to digital form for ease of mathematical manipulation.

(*e*) *Service Work.*—Demands for service work continue to be heavy. Some of the more important problems are listed below.

(i) *Electron Microscopy.*—Characterization of a polyhedral insect virus; morphological study of plant mitochondria; examination of several strains of bacteriophage; study of the peritrophic membrane from insect gut; identification of infective agent in certain plant virus diseases; study of the products of hydration cycle in kaolinite.

(ii) *Electron Diffraction.*—Identification of finely divided phases in clay and silica samples; identification of blemish on stainless steel; examination of aluminium films on mica for condensers.

(iii) *X-ray Diffraction.*—Identification of series of long-chain fatty acids; phase composition of iron oxides for town gas purification and its relation to efficiency; examination of ash from brown coal combustion; high-temperature study of mineral quartz of unusual thermal properties; phase composition of coal specimens.

(iv) *Spectroscopy.*—Investigation of ultraviolet absorption spectra of alkaloids; study of deterioration of paint films by reflection spectroscopy and establishment of colour standards; assay of chlorophyll concentrates; development of method for assay of antimony ores; spectrographic analysis of many alloy and mineral samples; systematic study of infra-red absorption of the porphyrins, compounds of considerable biochemical significance; study of the molecular structure of substituted sulphonamides; study of hydrogen-bonding in crystals of long-chain aliphatic compounds.

(v) *Mass Spectroscopy.*—Isotope analyses of gas mixtures from kinetic studies; determination of isotope ratios in nitrogen from metabolism experiments.

(*f*) *Instrument Laboratory.*—The major items completed in the past year include: recording differential refractometer; microtome for ultra-thin sectioning; vacuum evaporator for aluminizing 20-in. diameter zone plates; apparatus for micro-determination of nitrogen; amplifiers and power supplies for a variety of purposes; continuous circulation gas purification systems; ionization-type vacuum gauges; quantities of glass vacuum taps of special design; constant-pressure reaction system and control unit. The Instrument Laboratory has been responsible for the reconditioning, modernizing, and calibration of an ozone spectrophotometer and has advised on the production of large diameter gear wheels. The construction of a new electron diffraction camera, designed in the Section, is well advanced.

7. ORGANIC CHEMISTRY.

(Division of Industrial Chemistry.)

The research programme has continued in the main directions described in the previous Report and is chiefly directed to the study of the chemistry and utilization of wool wax and sugar-cane wax, the examination of Australian plants for alkaloids of possible pharmaceutical value and of substances toxic to livestock, plastics investigations with particular reference to the mechanism of the phenol-formaldehyde reaction, and the examination of seed oils from Australian plants.

(*a*) *Wool Wax Derivatives.*—Further work has been done on the alcohols and acids of wool wax and on a number of their derivatives. A study is also being made of the catalytic hydrogenations of the acids to convert them into the commercially more useful alcohols, and of the possibilities of using the acids in the preparation of modified alkyd resins. These investigations are described in more detail in Chapter XVI., Section 6.

(*b*) *Sugar-cane Wax.*—The systematic examination of derived waxes, prepared from the mixture of free fatty acids which results from the bleaching process, has been continued. These derived waxes are made by esterifying the carboxyl group with a polyhydric alcohol or by converting it to a diamide; the effect of such chemical modification on the physical properties has been studied, concentrating on the requirements for a solvent paste polish. The requirements of a hard wax for this use are exacting, so that if a derived wax could be made which satisfied them, it should be possible to make waxes from sugar-cane wax suitable for most industrial uses. The methylene and ethylene diamides and the pentaerythrityl ester waxes are the most promising of each group, and confer very high gloss on polishes made with them, while blends of the two groups are valuable in eliminating certain defects of each. The waxes mentioned compare very favorably with carnauba wax or its synthetic substitutes. It has also been shown that the differences in properties between bleached acidic waxes prepared with and without vacuum refining are reduced in their derivatives, and it appears possible that cheaper yet still useful derived waxes may be obtained by omitting the distillation under reduced pressure. A patent application covering the use of sugar-cane wax derivatives in polishes has been made. A patent covering earlier stages of the process has been obtained here and in the United States of America.

Solvent refining of crude cane wax has been further studied, principally in regard to the use of acetone at pressures above atmospheric.

(*c*) *Stock Poisons and Plant Alkaloids.*—Work on stock poisons continues to centre on the pyrrolizidine bases which cause liver damage in stock. Both heliotrine and lasiocarpine *N*-oxides have now been isolated directly from *Heliotropium europaeum,* as have three of the minor alkaloids. The importance of these amine oxides which accompany the parent bases has been confirmed in the Division of Animal Health, where it has been established that heliotrine *N*-oxide has qualitatively the same liver-damaging properties as heliotrine itself. Progress made with the structure of the more important of the minor alkaloids shows that it is closely related to heliotrine.

The alkaloids of *Crotalaria retusa,* now believed to be the species mainly responsible for Kimberley horse disease, have been isolated, and the principal constituent identified as monocrotaline. Ragwort (*Senecio jacobea*), which is troublesome in parts of Victoria, is under investigation, and, of the two main alkaloids previously reported, one has been shown to be identical with a base occurring in certain other *Senecio* species. Other plants shown to contain alkaloids, probably of the pyrrolizidine group, are *Echium plantagineum* (Paterson's curse or Salvation Jane) and *Amsinckia intermedia.* The latter has caused liver necrosis in stock in the United States.

In consequence of the experience gained with this group of alkaloids and of the fact that recognition of them by chemical means should be quicker, cheaper, and perhaps more certain than feeding tests, arrangements have been made to examine all plants belonging to pyrrolizidine-containing families which are under consideration for introduction into Australia. *Indigofera endecaphylla* has been examined in this regard; it contained a negligible amount of alkaloid.

An investigation of *Phalaris tuberosa,* in collaboration with the Divisions of Biochemistry and Animal Health, has been initiated with the object of isolating the neurotoxic principle which gives rise to "Phalaris staggers", a disease causing considerable losses on certain soil types.

Structural work on the unique vesicant alkalo
cryptopleurine continues, and progress has been made
the search for suitable methods of degradation. B
logical tests with cryptopleurine have shown that und
certain conditions it stimulates nerve regeneration.
does not retard the growth of rat carcinoma 2
Biological testing of D-magnocurarine (from *Gy*
carpus americanus) in the Physiology Departme
University of Melbourne, shows it to possess curarifor
activity, but its potential value lies in its activity as
ganglionic blocking agent.

Two new alkaloids have been isolated from
unnamed *Kopsia* species from north Queensland, a
progress has been made with the structural examinati
of them. Fractionation of the physiologically acti
water-soluble extract of the bark of *Balanops austra*
sica has led to the concentration of the irritant materi
and the recognition of the presence of two active pri
ciples.

Work has been commenced, in collaboration with t
Division of Entomology, on the extraction of timbe
immune to *Lyctus,* where there is evidence that t
immunity is due to the presence of a substance
substances toxic to the insects.

(*d*) *Fats and Oils.*—(i) *Investigation of Potent*
Seed Oil Resources.—The examination of native o
bearing plants for oils of possible industrial or scienti
interest is being continued. The seed-kernel oils
Alectryon subcinereus (Sapidinaceae) and of *Omphe*
queenslandiae (Euphorbiaceae) have been examine
Both are semi-drying oils; the latter may warra
further investigation because of its relatively high
content. The examination of the seed oil of t
Kerguelen cabbage, described last year, has been co
pleted; it is a semi-drying oil containing significa
amounts of C_{20} and C_{22} unsaturated acids, as do oth
members of the Cruciferae.

(ii) *General Chemistry of Long-chain Alipha*
Compounds.—With a view to the conversion of t
mono-unsaturated components of fats to more valua
materials, a study has been in progress of methods f
increasing the unsaturation of mono-olefines. T
principal difficulty is that the reagents examined sh
satisfactory activity with certain types of olefines onl
with others undesirable competing reactions occu
Attempts are being made to clarify the principles und
lying the different types of reaction and, if possible,
find means of making the reaction generally applica
for chlorination in the allyl position.

A research chemist of an industrial firm has spent t
current year working in this Section upon new outl
for fatty acids in this country. Several promising li
have been examined and some carried through to t
pilot-plant scale.

One of the officers working in the field of fats a
waxes spent a few months in the Chemical Resear
Laboratory at Teddington developing a vapour-pressu
method for the detection in long-chain organic co
pounds of small amounts of closely related impuriti
The method is capable of detecting, for example,
per cent. of palmitic acid in stearic acid.

In the determination of the structures of long-cha
compounds, it is often desirable to degrade the cha
in a controlled manner, with as little disturbance
possible to the functional groups. New methods f
effecting this are being studied.

Work in this Section on long-chain compounds oft
makes it possible to supply samples of chemical oth
wise difficult to obtain to people needing them.
number of samples of high molecular weight saturat
unsaturated, and hydroxy-acids have been made ava
able in this way to research groups in universities a
other institutions.

) *Plastics Investigations.*—(i) *Kinetics of the nol-formaldehyde Reaction.*—It is proving difficult nterpret the results so far obtained in the study of rate at which formaldehyde reacts with certain nols. An exact interpretation is being sought, with- the approximations and assumptions which have erto been made in published work on the subject. complicating factor is that the rate of the con- itant Cannizzaro reaction of formaldehyde is in- nced by the presence of the phenol. Moreover, riments have shown that the mechanism of this tion is still not clear. As a knowledge of this is ortant for the solution of the main problem, time had to be spent in seeking accurate values for the zation constants of formaldehyde and examining the mechanism of the Cannizzaro reaction.

i) *Aniline-formaldehyde Resins.* — Although iled work on this project ceased two years ago, e aniline-formaldehyde resins have been prepared the mechanical strengths of their mouldings nined. The object was to test whether certain itives, furfural and benzylaniline in particular, ld enable good mouldings to be obtained as they previously been shown to plasticize the resin. It found possible to lower the moulding temperature obtain high mechanical strengths; both initial ticizing and subsequent hardening could be obtained, both were insufficient for a good commercial mould- powder.

ii) *Tigaso Oil.*—A New Guinea oil, known by this other names, is an exudate of the tree *Campnosper- n brevipetiolatum* and a local article of commerce. e twenty years ago, work in the University of ensland showed that it was chemically similar to liquid secreted in the cashew-nut shell, a substance ch is the basis of a variety of phenolic resins greatly lemand for their chemical resistance and rubbery perties. The sample examined by the Queensland kers came from a different locality and differed in e of its properties from the material now under stigation. A study of its constitution is being ertaken, preparatory to investigating its value as a n constituent.

) *Microanalytical Laboratory.*—The microana- al laboratory is now well established, and its ser- s have been widely used by organic chemists of Organization, the universities, and industrial ratories. The range of determinations available teadily widening, and now includes carbon and rogen, nitrogen, oxygen, all halogens, sulphur, hoxyl, N-methyl, C-methyl, acetyl, active hydrogen, ecular weight, ashes and sulphate ashes, and ous metals. During the past year some 3,600 rate determinations were carried out, of which roximately 50 per cent. were for university workers, 25 per cent. each for the Organization and for istry. In addition, some special analytical investi- ons were done to assist an industrial laboratory their research programme on the pulping of wood n different eucalypt species.

nalytical research has also been in progress. Apart n general work on the improvement of standard cedures, this includes the development of new and e rapid methods for some constituents.

8. CHEMICAL ENGINEERING.

(Division of Industrial Chemistry.)

undamental studies of particular application in nical engineering are the investigation of liquid- our equilibria, the physical and chemical effects of n pressures, and the development of new chemical ineering techniques. These have been described er the heading of Physical Chemistry. The major investigations in the applied field have been directed to fuel research, but work has also been done on the fluid-bed roasting of alunite, and a start has been made on the construction of a large pilot plant for the conversion of copper concentrates to sulphates by roasting in a fluid bed.

(*a*) *Coal Utilization Research.* — Investigations related to the gasification of brown coal have been continued. An account of this work will be found in Chapter XX., Section 9.

(*b*) *Alunite Investigations.*—The utilization of Western Australian alunite as a source of potash fertilizer is vitally dependent on the control of the roasting process which breaks down the alunite structure and renders the potassium sulphate portion soluble in water. The industry based on this process, which was founded during the war, failed as an economic venture because, after treatment in the type of roaster used, a rotary kiln, only 65 per cent. of the available potash could be recovered in a soluble form. It became obvious that very close control of the temperature and other conditions was required during roasting to prevent the interference of secondary reactions by which potassium sulphate was again locked up in an insoluble form. It appeared that by roasting in a fluidized bed this control might be achieved. During the year a series of batch roasts was carried out in a 8-in. diameter fluid-bed roaster, to determine the optimum conditions for roasting alunite. The results were encouraging and plans are now being made to convert this unit to enable continuous roasting tests to be performed. It appears likely that yields of potassium sulphate of up to 90 per cent. may be obtained by this means; this would make the process more attractive economically. However, considerations of heat economy may make the design of the full-scale roaster somewhat complicated and expensive.

Concurrently with this work an officer located in the University of Western Australia studied the chemistry of alunite, and the convergence of these two approaches has led to his joining the group in Melbourne.

(*c*) *Roasting of Copper Concentrates.*—During the year the Organization entered into a co-operative arrangement with Mount Morgan Ltd. and the Mount Lyell Mining and Railway Co. Ltd. to build and operate a pilot plant incorporating a 3-ft. 6-in. diameter fluidized bed to investigate the sulphate roasting of their copper concentrates. Both companies believe that very great advantages may result from a major change in their processes for the recovery of copper and precious metals from mill concentrates. The new process involves roasting to obtain most of the copper in a soluble form as copper sulphate, leaching of the calcines, and electrolysis of the pregnant leach liquors. The gold and silver remain in the leach residues and may be recovered by cyanidation.

Until the advent of the fluidized-solids technique as applied to roasting, it was not possible to control the roasting conditions sufficiently to obtain the copper consistently in the desired form. Preliminary tests in fluid-bed roasters have given very favorable results but, because of the large capital expenditure which would be involved in such a major change in their operations, the two companies desire to investigate the process on a considerably larger scale before making a decision. The pilot plant envisaged will roast about 3 tons per day of concentrates.

Most of the equipment required for this plant has been delivered or is on order and erection has started. It is hoped to commence operations towards the end of 1953.

(*d*) *Process Equipment Laboratory.*—This year there has been an accelerated demand for the services of the Process Equipment Laboratory, chiefly for pilot-plant tests and large-scale extractions of natural materials preliminary to laboratory investigations. In all, seven pilot plants have been completed, fifteen tests have been carried out on process equipment, and 31 extractions made from natural materials. In a number of instances substantial savings in the cost of developing new processes have been possible as a direct result of the availability of pilot-scale equipment. The range of equipment available for this type of work has also been improved by the installation of a four-stage steam-jet air ejector and a modern single-drum rotary drier.

XIX. MINERAGRAPHY AND ORE-DRESSING.

1. General.

The importance of investigations for the development of the mining industry and the utilization of Australia's mineral resources has not been overlooked by the Organization.

Mineragraphic work to provide information on the mineral composition of ores has been in progress in Melbourne since 1927. The techniques used are highly specialized and require considerable experience, so that it is only rarely that they can be applied by the staffs of the operating mines. The current work of the Mineragraphic Investigations Unit is described in Section 2 of this Chapter.

The Ore-dressing Laboratories operated in Melbourne in collaboration with the University Department of Metallurgy and in Kalgoorlie in co-operation with the School of Mines investigate the composition of ores and provide advice on the most suitable methods for their full-scale treatment. This work is reported in Sections 3 and 4 of this Chapter.

Work on the utilization of minerals is carried out at the Division of Industrial Chemistry (*see* Chapter XVIII., Section 2). Work by this Division on the flotation of minerals is reported in Section 5 of this Chapter.

2. Mineragraphic Investigations.

(Mineragraphic Investigations Unit.)

Thirty-seven investigations have been carried out into the mineral association of rocks, drill cores, and mill products submitted by mining companies and institutions. Several of these are related to the search for new mineral deposits and twelve have been concerned with the experimental treatment of ores in the Ore-dressing Laboratories.

The latter include ores and concentrates from the Home of Bullion mine, Pioneer Scheelite mine, Coronet Hills mine, and the Peko mine in the Northern Territory, and from the Jackass mine at Inveragh and the Grasstree Gold mine near Mackay in Queensland.

During the year Dr. A. B. Edwards completed the editing of a symposium on the Geology of Australian Ore Deposits for the Empire Mining Congress in Australia in 1953. The work brings into a single, documented volume the substance of published and unpublished information on the composition, structure, and regional setting of Australian ore deposits.

A further study of the lead-zinc ores of Captain's Flat, New South Wales, has shown that the deeper levels of the mine maintain the same homogeneous composition and mineral relations that have been reported in the upper levels. Features in Keating's ore body which are repeated in the wide section of Elliot's ore body indicate that the behaviour of Keating's lode in depth may be a guide to the likely behaviour in depth of the northern section of Elliot's lode. Keating's lode, after attaining a maximum zinc: lead ratio of 2:1 on the 1,070-ft. level, has shown a decline in the zinc: lead ratio, in overall grade, and in metal content below this level.

A study of garnets at Broken Hill in all rock ty
from the lode outwards to the Hanging Wall gneiss
shown that they are all almandines and that there
no significant variation in properties or composit
that could be used to distinguish a particular bed
to indicate the origin of the garnets. Lode garnets
by contrast, rich in manganese and, in some cases, li
as well as manganese. The differences are striking
indicate that the conditions making for mangan
garnets or manganese-calcium garnets did not ext
beyond the confines of the lode.

Assays of bauxite from Napier's quarry, Mirl
North, have indicated, from time to time, that the wh
of the aluminium hydroxide is not present in the fo
of the trihydrate, gibbsite. The presence of the mo
hydrate, boehmite, was therefore suspected and
existence at Napier's quarry has been confirmed
X-ray powder patterns by Dr. J. McAndrew. X-
powder patterns have also confirmed the presence
tellurobismutite in the auriferous ore from the Gra
tree Gold mine, Queensland, the presence of halloys
as the siliceous impurity in the alunite ore fr
Bulahdelah, New South Wales, and the existence o
mixed layer hydromica in sandstone from the S
coalfield, Queensland.

The examination of specimens of oolitic iron forr
tion from north-west Western Australia directs att
tion to the possibility of the presence of low gra
oolitic iron ores in Australia. The specimens conta
much silica and no lime by comparison with Engl
oolitic iron ores, yet they indicate the desirability
further investigation of the deposits.

The investigations have been facilitated by contril
tions from a number of mining companies through t
Australasian Institute of Mining and Metallurgy. T
University of Melbourne has also co-operated in prov
ing laboratory accommodation.

3. Ore-dressing Investigations.

(Melbourne Laboratory.)

At Melbourne, where work is done in co-operati
with the Department of Mining of the University,
reports were issued (Nos. 423-452 inclusive). The
refer to the development of treatment methods for o
of gold, copper, lead, zinc, tungsten, and tin, and
work done on beach sands, magnetite, alluvial diamon
antimony slag, brown coal overburden, and brass dro

Together with investigations not yet completed, the
indicate continued interest in the treatment of tin a
tungsten ores, and in the recovery of gold from sulphi
concentrates produced at Victorian gold mines. The
is also a revival of interest in cobalt ores.

Work was done on the application of gravity a
magnetic methods of concentration to recover wolfra
and scheelite from a fine-grained ore from southe
New South Wales. The relative efficiencies of t
flow sheets, each of which involved stage-grinding a
concentration, were compared. An interesting featu
of this ore is that not only the wolfram but also a lar
proportion of the gangue is magnetic.

Following the investigation of samples of magnet
ore, a plant has been erected in New South Wales
provide magnetite medium for heavy media coal clea
ing plants.

Work reported in connexion with beach sands h
been to a large extent concerned with the production
high grade monazite concentrates. Work, not yet r
ported, has been done on the elimination of chromi
from an ilmenite concentrate by magnetic separatio
after heat treatment.

Investigation of an alluvial gravel from New Sout
Wales showed that the diamonds were very poor co
ductors, while the gravel (mainly quartzite and tourm
line) was relatively conducting. The relatively hig

ductivity of the quartzite was unexpected. Electro- ic separation was possible at a size coarser than esh. The company concerned has since built a pilot -type separator to carry out tests in the field.

Vork, not yet reported, has been done on the electro- ic separation of silica from granular lime-sand n Western Australian beaches. No appreciable aration was possible when the mixture was cold n after thorough drying. However, on heating to C. the silica developed strong negative charges the lime positive charges, which made possible emarkably good separation. The Western Aus- ian Department of Industrial Development has e built a pilot plate-type separator.

nvestigation of the rate of adsorption of caprylic l at a nickel-water interface indicated that the orption proceeded with no activation energy. The orption was reversible and followed the Gibbs orption equation. Multilayers of acid were formed the metal surface.

urther development of a polarographic method for determination of oxygen in treatment-plant solu- s has taken place. It is possible to determine the gen content of simple flotation and cyanide pulps te readily with an accuracy better than 5 per cent. s of Cl^-, SO_4^{2-}, CNS^-, $S_2O_3^{2-}$, $Fe(CN)_6^{4-}$ in con- trations normally met in practice do not interfere; her does 0.1 per cent. Cu. In the presence of zinc determination is possible but more difficult. Lead ow alkalinities has no effect, but at high alkalinities re is serious interference with the method. Further k is proceeding.

4. Ore-dressing Investigations.

(Kalgoorlie Laboratory.)

ixty reports were issued, and of these 20 covered allurgical investigations and the remaining 40 ered assays or analyses. Six investigations were cerned with gold ores or treatment problems. One these investigations gave a method of treatment a complex silver, gold, copper sulphide ore. ht reports dealt with the results of work on a iety of tungsten ores, and included the results of some t-plant work. Three lead-silver or lead-zinc ores e examined. The remaining three metallurgical estigations were shorter ones, and were concerned h spodumene, talc, and tin ore tailings. The assays analyses included a variety of determinations. A gold assays were made, but the work mainly con- ed of determinations which could not readily be le elsewhere in Kalgoorlie. The volume of inquiries technical assistance from industry was maintained. ring the year most of the equipment required for an -200 lb./hr. pilot plant was received.

5. Flotation Investigations.

(Division of Industrial Chemistry.)

ollowing some encouraging results from pre- inary tests, the Physical Chemistry Section of the ision of Industrial Chemistry has commenced intensive investigation of the flotation of cassiterite n an ore from Maranboy, Northern Territory.

XX. FUEL.

1. General.

he main research centre for the Organization's estigations on fuels is the Coal Research Section, ted at Ryde, New South Wales. The work of this tion is reported in Sections 2-7 of this Chapter.

he Division of Industrial Chemistry undertakes k on the engineering aspects of gasification and ization of low-rank coals, and this is reported in tion 9.

Co-operative investigations on the fossil pollen in brown coal are undertaken in the Botany School of the University of Melbourne, and are reported in Section 8. During the year a Consultative Committee for Brown Coal Research and Development was established to co-ordinate the separate endeavours of the State Electricity Commission of Victoria, the Gas and Fuel Corporation of Victoria, and the Organization in the field of brown coal research.

Coal Research Section.—This Section was established to undertake a fundamental and comprehensive study of the physical and chemical characteristics of Australian coals. The main object of this study is to make available for indigenous coals data on: (1) coking, gas-making and burning properties, and behaviour on carbonization and combustion; (2) the beneficiation likely to result from coal cleaning and preparation; (3) the most rational methods of thermal and chemical utilization.

The Section's laboratory is now being equipped for tar and gas analysis, and for the determination of ignition temperatures and reactivity of solid fuels. Accommodation for carbonization plant, coal combustibility test furnaces, and physical testing apparatus has been completed and a considerable portion of equipment installed. A building for coal washing equipment is nearing completion.

For maximum economy in the laboratory work connected with the search in New South Wales for coal deposits suitable for open-cut development, the Joint Coal Board has transferred its laboratory and staff at North Ryde to the Organization, which has undertaken the examination of bores drilled in this search by the Joint Coal Board and by the Bureau of Mineral Resources. Thus it is possible to include in the coal survey seams which might not otherwise have been available for many years.

Liaison between the Coal Research Section and the major coal producers and users in New South Wales has been established by the setting up of the Coal Research Advisory Committee as a sub-committee of the New South Wales State Committee of the Organization.

The Officer-in-charge, in his capacity as Australian member of the Commonwealth Committee on Fuel Research, continues to act as co-ordinator of reviews of fuel research dealing with physical testing of coal and petrographic investigations generally and with work on brown and sub-bituminous coals. Liaison continues to be maintained with Australian and overseas standards authorities. Senior officers of the Section have assisted to establish an active group of the Institute of Fuel in Australia. Fifty technical inquiries have been received during the year. Officers of the Section assisted in the presentation of a series of post-graduate lectures in solid fuel technology given under the auspices of the University of Sydney and the New South Wales University of Technology.

2. Examination of Coal Seams.

(Coal Research Section.)

(*a*) *Western Field of New South Wales.*—An initial survey of the western field involving the examination of some eighteen pillar and channel samples has been completed with the sampling of the cross measure drift driven by a New South Wales State coal mine. However, the information obtained from this drift was not as useful as expected, because of the poor development of the seams exposed between the Lithgow and the "dirty" seams.

(*b*) *Southern Field of New South Wales.*—A preliminary survey of the Bulli, Wongawilli, Tongarra, and Woonona seams of the southern field has been completed. Altogether 34 pillar or channel samples and seven deep bores were examined in the course of this work.

(*c*) *Northern Field of New South Wales.*—A survey of the Greta coal measures in the Maitland-Cessnock-Muswellbrook district of the northern field has commenced and samples have been obtained from three of the five collieries working the Homeville seam.

Samples from the available Tomago series, including the Donaldson's Rathluba, and Big Ben seams, from four collieries in the East Maitland district, have been examined.

A further number of samples from trial shafts put down by the Joint Coal Board in the Muswellbrook-Singleton district has been examined. The shafts penetrated uncorrelated seams, probably Muswellbrook-Greta and associated seams, in the Balmoral-Broke open-cut areas. The four or five seams in this area are of variable thickness. Although comparable in ash content, they are generally lower in volatile matter, have variable coking properties, and are inferior for gas-making to the Greta coal of the Cessnock area. One or possibly two of the seams are second-grade gas coals.

Nine deep bores, put down by the Joint Coal Board in its deep drilling programme to determine structure in the northern district, have been examined. These penetrated the Wallarah, Great Northern, Fassifern, Pilot, Australasian, Montrose, Wave Hill, Fern Valley, Victoria Tunnel, Young Wallsend, and Borehole seams and some others so far uncorrelated.

Reports on 160 cores from bores drilled in connexion with the Joint Coal Board's open-cut programme have been prepared.

3. COMBUSTION PROPERTIES OF AUSTRALIAN COALS.

(Coal Research Section.)

The importance of this field of fuel utilization can be gauged by the fact that it absorbs more than half the Australian deep mine coal. It is not yet possible to predict the behaviour in use of Australian coals from the results of chemical analysis or from abnormalities observed with respect to the methods of classification of coal used overseas. Because of this, and to establish correct usage of various types of coal, a survey of the ignition and combustion characteristics of Australian coals with particular reference to the evaluation of coal for combustion is being carried out.

Experience has shown that no one burnability test can be used universally to assess combustion characteristics of a fuel under all conditions of use. Therefore equipment for carrying out tests on the reactivity of coal and coke, determinations of ignition temperatures of solid fuels, the rate of propagation of ignition in beds, the inflammability of coal dusts in suspension, and the burning of coal and coke fired in underfeed and overfeed fuel beds has been installed. Work has also been carried out to establish the technique of operating an experimental furnace for measuring the velocity of ignition of different coal types. The pilot-scale combustion furnaces for studying the burnability of coal fired in underfeed and overfeed fuel beds are almost complete. Preliminary tests have been carried out to determine the permeability of fuel beds, in order to arrive at standard conditions for use with these furnaces.

The ignition temperature of a number of represe
tive Australian coals over a wide range of rank
been determined, and correlations with other prope
are being made. Typical results are: Collie
(Western Australia), 124° C.; Greta coal (New S
Wales), 150° C.; Moorlands coal (South Austra
160° C.; Bulli coal (New South Wales), 172-177
It is interesting to note that the ignition temperat
of coal from Blair Athol, Callide, Yallourn,
Lithgow are within a narrow range of 142°-146
and that Collie coal is the most reactive of Austra
coals as indicated by this method.

4. CARBONIZING PROPERTIES.

(Coal Research Section.)

The carbonizing properties of Australian coals
being investigated using a pilot-scale plant simila
that designed jointly by the United States Burea
Mines and the American Gas Association. Du
the year, this has been completely overhauled, st
tural modifications made, and the plant reassemble
a new building. Results of test runs previously car
out on coal from the Liddell, Nattai Bulli, and G
seams are being computed.

5. PHYSICAL PROPERTIES.

(Coal Research Section.)

Knowledge gained from the physical testing of
is essential for good mining practice and the deve
ment of efficient coal handling and crushing pl
The growing demand for pulverized fuel and
increasing attention being paid to the sizing
cleaning of coal emphasize the importance of invest
tions into size degradation processes. Studies of
physical properties of coal include measurements
coal strength, friability, particle size distributio
the broken material, resistance to breakage by a
tion and by impact, grindability, and abrasive
The installation and testing of equipment for carr
out abrasion and grindability investigations have
commenced.

6. COAL CONSTITUTION.

(Coal Research Section.)

(*a*) *Permanganate Oxidation.*—Further sample
coal have been tested in connexion with the invest
tion of the correlation between rank and reactivit
boiling alkaline permanganate. The effect of dr
of earthy brown coal on its permanganate reacti
was examined and found to be negligible.

(*b*) *Petrography.*—The stratigraphic zoning of
Permian coal-measures in New South Wales pres
difficulties since the absence of reliable zone ma
fossils has made the precise intercorrelation
separate coal basins a difficult task. The possibilit
using the distribution of certain microspores for
purpose as well as for correlating individual
seams is being investigated. The work of classify
cataloguing, and studying the distribution of s
types in major coal beds has commenced, and a
report on the spore flora of the Lithgow seam has
drafted. The investigation of the petrographical
position of Australian coals by the microscopic ex
nation of thin sections using transmitted light an
polished and etched sections using incident light,
tinued throughout the year. Profiles of the B
Tongarra, Top Greta, and portion of the Main G
seams are being studied.

(*c*) *Minor Constituents.*—The examination of
ashes by emission spectrography has continued
semi-quantitative estimations made of the elem
present. Preparations are being made for quantita

timations. Examination of composite samples from e Bulli seam show traces of manganese, nickel, pper, molybdenum, and lead, and vanadium and zinc larger quantities. All these elements are present in e Bulli seam throughout the coal-field, but cadmium d zirconium have been detected in coal from the rthern area only. The occurrence of germanium in antity higher than is usual has been detected in a mple from the seam taken in the Burragorang alley.

(*d*) *Mineral Matter-Ash Relationships.*—In order to assify and compare coals for certain purposes, it is cessary to know accurately the carbon content of the re coal, that is, mineral matter and moisture free al substance.

Estimation of the mineral matter in coal is usually ade from a knowledge of the composition of the ash, t this is a laborious process and a method of estimat- g mineral matter in coal which does not involve deter- ination of ash composition is desirable. The relation- ip between mineral matter and ash in Australian als is being investigated using several different chniques.

A study of the examination of coal by ultraviolet ght microscopy has established that, owing to very rong absorption, it is not practicable to obtain trans- ission photomicrographs of thin sections of coal or ke with ultraviolet radiation. Transmitted ultra- olet radiation reveals finer structural detail in some inerals, but used alone is not suitable for their entification. Work on the examination of coal by -ray diffraction has commenced, and identification some minerals present has been made. In the Bulli d Tongarra seams occurrences of well-preserved wood ucture have been observed, in which the agent of trification has been shown to be kaolinite.

7. Methods of Analysis.

(Coal Research Section.)

Generally, the methods of analysis used by this ction are those specified by the Australian and itish Standards institutions or by the British Fuel search Station. Investigations of and comparison th other methods continue.

(*a*) *Approximate Ash Analysis.*—It has been sug- sted that the tendency of a coal ash to form clinker y be predicted from an estimation of the water- uble, acid-soluble, and insoluble fractions of the n. This approximate ash analysis is stated to be s time-consuming than the full silicate analysis, and method and its usefulness as applied to Australian als have been investigated during the past year.

(*b*) *Direct Determination of Oxygen in Coal.*—The ygen content of coal may be determined either by ference after the estimation of other constituent ments or directly by the incorporation of the oxygen determinable compounds. These methods applied to h a complex and heterogeneous substance as coal are ble to error, and methods for the direct determina- n of oxygen are being investigated.

(*c*) *Sulphur in Coal.*—Some coals are difficult to for certain purposes because of their high sulphur ntent, and investigations have been continued into occurrence of different forms of sulphur in coal. has been found that coal thio-ethers react with methyl lide as dialkenyl sulphides and not as dialkyl phides.

(*d*) *Tar Analysis.*—Analyses of tars from the bonization plant have continued and a number of thods of determining the constituents of coal tar being investigated.

8. Microstructure of Brown Coal.

(Pollen Research Unit.)

The Pollen Research Unit at the Botany School, University of Melbourne has continued studies on the fossil pollens in brown coals. Five papers have been published during the year on this work. Samples from Comaum, South Australia, are being investigated and it has been shown that the pollen content of a coaly deposit occurring at 620 feet is completely distinct from that of a sandstone at 650 feet. The composition of the younger flora is identical with that of a Tertiary clay at Wensleydale, Victoria, whereas the older has a Jurassic aspect. The Unit is also studying Cretaceous rocks from various parts of Australia in the hope that the pollen in these rocks will shed light on the development of the Tertiary flora.

9. Utilization of Low-rank Coal.

(Division of Industrial Chemistry.)

Investigation of the gasification of Victorian brown coals has continued. Modifications have been made to the coal feed equipment, and to the control system of the fluidized bed synthesis gas pilot plant and a number of experimental runs has been completed. The analysis of the experimental data from these runs is complicated by the difficulty of determining accurately the water vapour content of the product gas. Many of the proposed methods for carrying out this determination have been investigated experimentally but a completely satisfactory method has not yet been devised.

The erection of equipment required for the investigation of the production of gas of high calorific value by the pressure gasification of brown coal is nearing completion. The equipment is designed to investigate under continuous steady-stage conditions the reaction between brown coal and carbon monoxide-hydrogen mixtures at pressures up to 50 atm. The aim of this work is to obtain information on the mechanism and rate of methane formation during pressure gasification, and to make a preliminary evaluation of a new two-stage pressure gasification process. The first part of the pilot plant, which has been designed to produce and store up to 3,000 cubic feet of a hydrogen-carbon monoxide mixture in a given ratio, has been completed and tested. The erection of the second part, the actual reaction system, is well advanced.

The major pilot-plant projects described above are being supported by fundamental studies related to the gasification of coal. The study of the catalysis of the gasification reaction by ash constituents has been continued, and subsequently completed as far as the water-gas shift reaction is concerned. Some work has been carried out on the influence of inorganic constituents on the reactivity of carbon towards steam, and attention is now being given to the catalysis of methane synthesis by ash constituents. Apparatus has been built to study the flow and diffusion of gas within the pores of the powdered solid catalyst and to determine the pore size and distribution in coal-char particles. Some progress has been made on the investigation of the influence of pressure on the kinetics of the carbon-steam reaction but it has been limited by shortage of staff.

XXI. PHYSICAL METALLURGY.

1. General.

A considerable programme of research in metallurgy is undertaken at the Section of Physical Metallurgy established in the Research School of Metallurgy at the University of Melbourne under Professor J. N. Greenwood. This work is described below. Work on metal physics is in progress within the Division of Tribophysics (*see* Chapter XXII.).

The work of the Division of Industrial Chemistry on foundry sands is reported in Chapter XVIII., Section 4.

Section of Physical Metallurgy.—The investigations have progressed along the lines indicated in the previous Annual Report, the main topics being: titanium alloys, the oxidation of titanium, and the mechanism of plastic deformation in metals.

Advice has been given to industrial firms and Government Departments on a wide variety of topics including heat-treatment problems, prevention of corrosion, the selection of alloys for unusual applications, and the use of the new microscopical techniques which have been adapted by the Section for the study of metallurgical problems.

Officers of the Section have continued to assist in the training of post-graduate students.

2. TITANIUM AND ITS ALLOYS.

(Section of Physical Metallurgy.)

(*a*) *Alloys.*—The chief aim of this work has been to provide a general understanding of the factors which affect the alloying properties of titanium. The study of titanium alloys containing elements with atomic sizes close to that of titanium has been continued and detailed investigations of titanium-tin and titanium-silver alloys have been completed. The results of these and earlier investigations by the Section have been considered together with results from overseas laboratories, with a view to deducing empirical laws relating to the formation of solid solutions in the allotropes of titanium. It has been found that solutions of non-transitional elements in both forms of titanium seem to conform with rules relating to atomic size and crystal-lattice geometry. Solutions of the transitional metals in the high-temperature form of titanium also appear to obey these rules, but solutions in the low-temperature form do not.

(*b*) *Reaction with Oxygen.*—The extremely rapid oxidation of titanium and its alloys at temperatures in excess of 500° C. is a major problem in the development of these materials for use at high temperatures. It has been found that the diffusion of oxygen in the titanium metal during the progress of oxidation largely governs the rate at which the oxidation proceeds. This is unusual because, in general, the oxidation of metals and alloys is almost invariably controlled by the diffusion of metal or oxygen through the intervening oxide layer.

An oxidation mechanism which is controlled by diffusion of oxygen within the metal itself suggests that the high-temperature oxidation of titanium may be reduced by suitable alloying of the metal. This aspect will be investigated. An X-ray diffraction study of the lower oxides of titanium has been completed and the results have been used in interpreting the composition and structure of various oxide scale layers formed during the oxidation of titanium.

(*c*) *Chemical Studies.*—The chemical compositions of the oxide scales formed on the surface of metallic titanium in the oxygen surface-reaction work have been investigated. It has been found that the presence of some metallic foreign elements can have an important effect on the oxidation rate. Chemical methods have been used to verify the oxygen distribution between the scale and the metal.

The reactions between titanium monoxide, sesquioxide, and non-stoichiometric dioxide and chlorine have been investigated.

The thiocyanate-tungsten reaction is being investigated as a method for the estimation of tungsten in titanium metal.

3. CREEP OF LEAD AND ITS ALLOYS, ALUMINIUM AND ZINC.

(Section of Physical Metallurgy.)

The use of lead and lead-thallium alloys as c venient materials on which slow deformation ca studied at room temperature has been continued. the same time, the effect on the creep characteri of additions of an alloying element (thalli within the range of solid solution have been relate (*a*) grain size in relation to cross-sectional are specimen, (*b*) grain refinement in alloys whose latt spacing is very close to that of lead, (*c*) increa crystal strength in other alloys. Alloys in groups and (*b*) may be regarded as pure lead of varying gr size and have been used in detailed observations microstructural changes during creep. Ordina microscopy was supplemented by the techniques phase-contrast, multiple-beam interferometry, polariz light, and X-ray diffraction. It has been found t there is a complex interrelation of various types of s deformation bands, and surface steps with bodily mo ment and rotation of grains and migration of th boundaries; this relation also depends on grain s and rate of strain. A sub-structure in X-ray refl tions has been observed under specific conditions, b this does not appear to correspond with sub-grai as in aluminium.

The above investigations have led to a re-examinati of work on the creep of lead-tellurium alloys, whi crack markedly. In consequence, collaboration wi the School of Metallurgy has been extended and n experiments are in progress; already, the influence grain size has been found to be important.

In conjunction with the Metallurgy Resear Department of the University, an investigation into t formation and development of sub-structures aluminium and zinc has been carried out, usi polarized light and multiple-beam interferomet The main result emphasizes the importance of def mation bands.

XXII. TRIBOPHYSICS.

1. GENERAL.

The Division of Tribophysics has developed from t former Lubricants and Bearings Section establish during the war to assure essential information to A tralian engineering industry in the manufacture bearings for aero and other engines. The origi investigations have been continued and extended include fundamental studies in metal physics and wo on reaction kinetics. Major advances have been ma in the knowledge of distortions in metals produced plastic deformation, of phase changes in metals, a of the mechanism of slow combustion of hydrocarbon

Division of Tribophysics.—During the past year major advance has been made in the understanding the disturbances which are produced in a metal plastic deformation, and it has been possible to correl distinct types of disturbances with changes in prop ties of a metal caused by this deformation.

The new laboratory built for the Division in t grounds of the University of Melbourne has partly be occupied. Thanks are due to the University of M bourne for the generous hospitality the Division h enjoyed since its inception, in the Chemistry Scho Active co-operation with the Chemistry, Metallur Physics, and Engineering Departments has continued

Frequent advice and assistance was given to ma industrial and governmental organizations and offic of the Division have continued to act on various co mittees, in particular the Engineering Group Co mittee.

2. Properties of Surfaces.

(Division of Tribophysics.)

Apart from investigations on some practical aspects friction and lubrication, the work on the physics d chemistry of solid surfaces is concerned mainly th the effects of the arrangement of the atoms in the rface on its properties. Work is also being done such properties of silicone oils as are important for brication and surface protection.

(*a*) *Bearing Testing.*—The relative properties of Babbit and cadmium-silver bearings have been vestigated mainly in relation to running-in and zure behaviour. The Babbit bearing appears to be s sensitive to overload or other extreme conditions ring run-in than is the cadmium-silver and will more sily heal up local seizure damage with negligible loss ultimate performance.

Tests on very narrow bearings with length : diameter tio down to 0.25 show that high loads can be carried low friction values provided that clearance is small ough to minimize side-leakage of the lubricant. der these conditions, the geometric accuracy and rface finish of the journal surface becomes more portant, and the effects of these variables are being vestigated. There is some evidence so far that very ooth journal surfaces, such as may be obtained by perfinishing, run the bearing in very slowly and are ore liable to seizure during this stage.

(*b*) *Adsorption.*—Information on adsorption on id surfaces is being obtained by a study of the rticular phenomena exhibited by the adsorption of g-chain polar (amphoteric) compounds. The work at present concerned with monomolecular films of bstances either soluble or insoluble in water. It has en found that some of these substances adsorb from aqueous solution to form a hydrophobic layer only er a restricted concentration range which depends on the substrate material.

Stearic acid is insoluble in water and can form a film monomolecular thickness on a water surface. This n can then be transferred to a solid surface where it subsequently adsorbed. The mechanical properties the films on water are profoundly affected by small ncentrations of metallic ions in the water. The olecular packing in compressed films has been found change abruptly at pH values which coincide with ose for precipitation of the metallic ions in the ueous substrate.

(*c*) *Diffusion.*—The diffusion of certain organic mpounds over the surfaces of metallic single crystals d quartz glass is being studied. A radioactive sulur atom is chemically incorporated into the comund whose distribution over the solid surface can be en accurately traced with a special Geiger counter. e technique will reveal the presence of extremely nute quantities. Measurements with low activity rcaptostearic acid, on silver and quartz glass, have own that diffusion of this compound (if it occurs at) takes place by the movement of molecules in a layer monomolecular thickness or less. This is observed temperatures up to 50° C. above the melting point of acid. More sensitive experiments with higher tivity material are needed to elucidate the process rther.

(*d*) *Catalysis on Single Crystal Surfaces.*—The vestigation of the influence of the atomic configuran of a surface on its catalytic properties has conued. The method of preparing single crystals in form of thin sheets has been improved. Measureents of the rates of the zero-order decomposition of rmic acid vapour on silver crystals have shown that activation energy for the reaction depends strongly on the orientation of the crystal, being lowest when the most densely packed atomic layers lie parallel to the surface. An apparatus is being constructed for the study of adsorption on the crystal surfaces with a view to obtaining close insight into their catalytic properties.

3. Metal Physics.

(Division of Tribophysics.)

The work is concerned with the plastic properties of metals and with the mechanism of phase changes. A better understanding of these phenomena should make it possible to state the optimum conditions of a material for its various applications.

(*a*) *Plastic Deformation.*—It is recognized generally that plastic deformation of metals occurs by the motion of lattice imperfections known as dislocations. However, it is likely that other types of imperfection, such as vacant lattice sites and interstitial atoms, are created during deformation. The presence of such imperfections causes a small percentage of the energy expended during deformation to be stored in the metal. This stored energy is released when the deformed metal is heated and, from determinations of the magnitude of the energy stored and the temperature at which the energy is released, information may be obtained concerning the imperfections present. By combining these measurements with those of other properties, such as resistivity, hardness, and macroscopic density, it is likely that the parts played in plastic deformation by the various imperfections may be determined.

(i) *Energy Stored in a Metal during Deformation.*—In previous experiments on pure copper practically no liberation of energy was detected below the recrystallization temperature and it is likely that in this case the only stored energy measured was that associated with dislocations. With such pure metals any energy stored in the form of vacant lattice sites could be liberated at room temperature and thus would not be detected with the present apparatus. This difficulty is overcome by using higher melting point metals, and also by the addition of impurities to the lower melting point metals.

Measurements have been made on nickel of commercial purity. With this metal a large percentage of the stored energy is released well below the recrystallization temperature and this release of energy is associated with the disappearance of the majority of the increase in resistivity due to the deformation but does not cause any reduction in hardness. As in the case of pure copper the release of the remaining energy occurs at the recrystallization temperature and is associated with a sudden drop in hardness. These measurements, when combined with those of macroscopic density, suggest that a considerable proportion of the energy stored during plastic deformation resides in the form of vacant lattice sites. A similar series of measurements is being made on arsenical copper.

The manner in which the release of energy associated with vacancies and with dislocations varies with the amount of deformation is being studied.

(ii) *Shape of X-ray Interference Lines.*—Reproducible measurements of line shapes have been made on annealed and deformed specimens of filed copper and some measurements also on solid nickel specimens deformed in torsion.

The X-ray spectrometer has been improved further by the addition of a new monitor which functions on the X-ray beam leaving the crystal monochromator and thus compensates for any variations in intensity due to the monochromator itself.

(iii) *Changes in Electrical Resistivity due to Coldworking.*—The difference in electrical resistivity between a deformed and an annealed wire has always been found to be independent of the temperature at which the resistivity was measured. In collaboration with the Division of Electrotechnology a method of measurement of very high accuracy has been developed. The results show that the difference is smaller at higher temperatures for all metals and alloys investigated. This means that the contribution to the electrical resistivity by the thermal vibrations of the atoms is not independent of that due to lattice disturbances produced by deformation. Probably the atomic vibrations are different in deformed and in annealed metals.

(iv) *Continuity of Slip Lines across a Grain Boundary.*—Slip lines on the surfaces of polished and subsequently strained specimens of aluminium and 70/30 brass are sometimes continuous across a grain boundary. Investigation of the interior of the brass specimens shows that this is not merely a surface effect but that the line of intersection of the slip planes in the two crystals does lie in the grain boundary. When the duration of annealing, prior to the final deformation, is increased there is within a given surface area, an increase in the number of grain boundary sections where slip lines cross. It is, therefore, suggested that the boundary configuration favorable to slip line crossing has a low interfacial free energy.

(v) *Recrystallization.*—The use of polarized light to study inhomogeneities of deformation in polycrystalline specimens of zinc has been found not to yield an unequivocal index of these phenomena. The possible use of various other techniques has been investigated without success. At present, metallographic studies of the free surface of deformed specimens and examination by means of polarized light are being employed to study the inhomogeneities, with a view to determining their relation to the erratic growth of new grains observed during recrystallization.

(*b*) *Phase Changes.*—Phase changes in solids are of two types. In the first type the nucleation and growth of the new structure are effected by means of the thermal movement of the atoms (diffusion). In the second type, thermal movement plays no part and the transformation can occur extremely rapidly at very low temperatures. This type (martensite transformations) occurs by small displacements of atoms relative to each other so that each atom in the new structure has the same neighbours as it had in the old. The atomic displacements can be deduced from various observable geometrical features of the transformations.

The theoretical study has been continued and the formulation of the theory developed has been generalized. An adequate test of the validity of this theory will involve the comparison of the predicted and observed geometrical properties of many individual transformations. So far, such comparisons have been made for the face-centred cubic to body-centred cubic martensite transformations in iron-carbon, iron-nickel, iron-nickel-carbon, indium-thallium, and copper-manganese alloys, and also for the diffusion transformations in copper-beryllium and copper-gold. The theory is in agreement with observation for all these transformations and the geometrical similarity of the two types of transformation is partly established.

Experimental investigations of the order-disorder transformation in copper-gold and of the precipitation of the copper-beryllium phase from the supersaturated α-solid solution are still in progress.

4. Reaction Kinetics.

(Division of Tribophysics.)

The kinetics group has been concerned mainly with two problems: the study of the kinetics of oxidation of organic compounds and the measurement of thermal conductivities of organic vapours.

(*a*) *Kinetics of Oxidation of Organic Compound*
—Oxidation of hydrocarbons and other organic com
pounds occurs by a highly complex chain reaction. I
many cases the intermediate formation and decom
position of peroxides have an important bearing on th
progress of the reaction. Oxidations in the gas phas
are also influenced by the transitory production
aldehydes. Details of reaction mechanisms, howeve
are obscure, though some progress has been made. I
the present work, three aspects of the problem hav
been studied, the systems being chosen to eliminate con
plicating factors: (i) the kinetics of peroxide forma
tion from benzaldehyde in solution, (ii) the mechanis
of the early stages of the oxidation of propylene
the gas phase, and (iii) the mechanism of decompos
tion of benzoyl peroxide in the presence of phenol
and other anti-oxidants.

(i) *Kinetics of Oxidation of Benzaldehyde.*—Wor
has continued on both the peroxide-catalysed and t
uncatalysed reaction. The rather unexpected kinet
behaviour of the uncatalysed reaction found previous
has been shown to occur over a wider range
conditions.

(ii) *Mechanism of Oxidation of Propylene.*—T
rate of development of the reaction in the early stag
depends on the formation of formaldehyde and high
aldehydes. Formaldehyde is produced progressively
a slowly branching chain reaction. Higher aldehyde
on the other hand, appear relatively abruptly and cau
an immediate rapid acceleration of the reaction. T
evidence suggests that the higher aldehydes are form
as a result of the decomposition of peroxides which a
produced by a similar mechanism to that which obtai
in the simpler liquid-phase reactions ((i) above
Peroxides, thus, do not promote the oxidation direct
but act via the production of aldehydes.

(iii) *Effect of Phenols on the Rate of Decompositi*
of Benzoyl Peroxide.—Benzoyl peroxide decompos
simultaneously by a molecular and a chain reacti
The chain reaction is suppressed by the addition
phenols, but in some cases there is an optimum co
centration beyond which the phenol causes acceler
tion. The magnitudes of the inhibiting and prom
ing effects depend on the molecular structure of t
phenol, the nature of the solvent, and the presen
of other inhibitors. The results suggest that the vi
commonly held regarding the mechanism of inhibiti
by phenols requires revision.

(*b*) *Thermal Conductivities of Organic Vapours.*
Work on the thermal conductivities of organic vapou
has been continued and the temperature range of t
measurements extended up to 200° C. The resu
have been used to make a detailed examination of t
relation between thermal conductivity and viscosi
For non-polar vapours the effect of temperature
this relation is found to be in accord with theoreti
expectation. For polar vapours, however, disc
pancies occur which are attributed to exchange
the translational and external energy of the molecu
in collision.

XXIII. NATIONAL STANDARDS LABORATORY.

The National Standards Laboratory was founded
1938 as a result of the Commonwealth Governme
decision to extend the activities of the former Cou
for Scientific and Industrial Research to seconda
industry. Its main purpose is to maintain prec
standards of measurement for the Commonwealth
to provide a calibration service for science and ind
try. The Laboratory is established in the grounds
the University of Sydney, and is now able to meet m
of the requirements of industry and governmental

ai-governmental authorities for the calibration of -standards and precision measuring equipment in ms of internationally recognized standards of asurement.

Legal status is given to the standards of measure- nt maintained in the National Standards Labora- y, by the *Weights and Measures (National Stan- rds) Act* 1948, which makes the Organization the stodian of the national standards of measurement. der this Act the standards of measurement of the ates are derived from the Commonwealth standards measurement maintained by the National Standards boratory. The Commonwealth legal units and ndards of measurement are to be defined in Regula- ns made under this Act, which also provides for a tional Standards Commission to advise the Com- nwealth Government on weights and measures.

The statutory functions of the National Standards boratory in maintaining standards, testing, and cali- ation are carried out by the Divisions of Metrology, ysics, and Electrotechnology. The three Divisions the Laboratory carry out research in matters ectly related to the maintenance of standards of ecision measurement, and also provide an important vice to industry by giving advice on methods of asurement and by investigating special problems. e Divisions also engage in research of a more ndamental kind.

Last year an invitation was received from the Inter- tional Bureau of Weights and Measures to take part an international comparison of end standards of gth. The construction of the end standards in the boratory and the necessary measurements have been npleted and the standards forwarded to the Bureau measurement. A similar invitation has since been eived from the Bureau to participate in an inter- tional comparison of temperature standards used in maintenance of the International Temperature ale below 630° C. A comparison is also in pro- ess between the Laboratory and the National Physical boratory, Great Britain, of standards used in main- ning the Scale in the optical pyrometer range, that above 1,063° C.

The issue of a series of test pamphlets giving details the work of the Laboratory and the tests carried t was begun during the year. These pamphlets cover following fields: (i) engineering metrology;) heat, hygrometry, and viscometry; (iii) optics d photometry; (iv) electricity and magnetism.

Details of the work of the Divisions of Metrology, ysics, and Electrotechnology are given in Chapters XIV., XXV., and XXVI., respectively.

XXIV. METROLOGY.

1. General.

For efficient and economic methods of production be maintained in industry accurate measurements e essential. Measuring equipment must therefore checked and calibrated at regular intervals against rking standards of measurement which are in turn librated against national standards maintained by e Division of Metrology.

Division of Metrology.—The Division as part of the ational Standards Laboratory is responsible for the mmonwealth standards of measurement of length, ass, and time interval, and the associated physical antities.

The main effort of the Division has been directed wards statutory and industrial requirements in spect to national standards, but the Division also gages in research on matters concerned with pre- sion measurements in metrology and applied mechanics. The most important project of the year was the production and measurement of three end standards and platen for an international intercomparison arranged by the International Bureau of Weights and Measures.

The Division took a prominent part in the Exhibition arranged by the New South Wales Division of the Institute of Physics. The work of the Division was inspected by groups from the Australian and New Zealand Association for the Advancement of Science, Departments of Education, Government Departments, and industry. Addresses have been delivered to technical institutions and gatherings and co-operation has been maintained with governmental and semi-governmental institutions and technical bodies. Officers have taken part in the work of the Standards Association of Australia; they have served on Advisory Committees and panels of assessors of the National Association of Testing Authorities, and on the Optical Munitions Technical Advisory Committee.

2. Length and Associated Quantities.

(Division of Metrology.)

(*a*) *Standards.*—(i) *Line Standards.*—Two new line standards, a yard and a metre, have been received and are to be used as Laboratory reference standards. Both standards are of 58 per cent. nickel steel. The metre standard has been calibrated by the International Bureau of Weights and Measures. The yard standard will be calibrated at the Laboratory by comparison with the standard yard already held by the Laboratory.

Extensive intercomparisons have been made between the Laboratory standard yard and two-yard standards, made in 1845, which are very similar in construction to the Imperial Standard. The results obtained showed that the difference in length between the old standards had remained substantially constant, but their actual lengths were found to depart from their original values by a significant amount.

(ii) *End Standards.*—A set of reference end standards, ranging in size from 4 to 36 inches, have been received. These bars, which have been calibrated at the National Physical Laboratory, will form the basis for end measurement at the Laboratory.

It is proposed that these bars shall ultimately be calibrated in terms of the Laboratory's standard yard, and the necessary equipment to effect the transfer from line to end measure is being manufactured at the Laboratory. Measurement of the shorter bars, up to 18 inches, by interferometric methods is to be undertaken at an early date.

(*b*) *Universal Comparator.*—This comparator has had considerable use during the year. The control and measurement of the temperature inside the tanks has been a major problem. Consideration has been given to improving the design of the tanks to enable more satisfactory control.

(*c*) *Geodetic Base.*—Necessitated by the apparent movement of some of the microscope piers under the weight of the 4-m. carriage, modifications to the base have been completed and this movement has been reduced to a negligible amount. Work is now proceeding on the calibration of the 4-m. standard prior to the calibration of the base itself.

(*d*) *Dividing Engines.*—Several scales have been produced by the double evaporation process and the technique developed to permit the production of lines up to 0.002 inch thick. Other work has included the graduation of invar tapes, and the production of precision sector disks for the Division of Physics.

(*e*) *Gears and Gear Hobbing Equipment.*—Mathematical investigations on the geometry of gears and hobs have been continued and theoretical work on the elastic deformation of gear teeth under load is being undertaken.

(*f*) *Interferometry.*—Further work has been done on the development of equipment for the determination of long lengths directly by interferometry. Multiple-beam interferometry has been used in problems connected with the surface structure of metal surfaces, the optical properties of thin films, and phase-change effects at metal surfaces. The coating plant has been used frequently for the deposition of various metal and dielectric films.

A krypton 86 isotope lamp has been received from the Physikalisch-Technische-Bundesanstalt, Brunswick, Germany, for use in experimental studies with other isotopic light sources.

A group of end standards has been measured directly by interferometry and forwarded to the International Bureau of Weights and Measures, Sèvres, France, for an international comparison of standards from eight national laboratories. This work, together with wavelength determination of isotopic light sources, is part of a general study by national laboratories of the suitability of one of the wavelengths emitted from such sources as the ultimate unit of length.

(i) *International Calibration.*—Measurements were done on end bars 50, 75, and 100 mm. in length using the Kosters interferometer that has been recently completed and an electrodeless mercury 198 isotope lamp.

(ii) *Kosters Interferometer and Wavelength Determinations.*—As indicated in last year's Report the Kosters interferometer is being used to measure lengths directly by interferometry. With an electrodeless mercury 198 lamp lengths of up to 18 inches can be determined directly in terms of light waves. Equipment for the control of temperature to 0.001° C. and the determination of lengths in vacuum has been completed. Equipment for the measurement of temperature to 0.001° C. is almost completed.

(iii) *One-metre Interferometer.*—The detailed design of this equipment is proceeding and all optics have now been received.

(iv) *Multiple-beam Interference Comparator.*—A comparator has been designed for comparing end standards with high precision using sharp multiple-beam transmission fringes. The comparator will take standards up to 1 m. in length, and it avoids the need for calibrated levels as used in the level comparators.

(v) *Interference Microscope.*—A simple interference microscope has been set up permanently using an ordinary microscope with a vertical illumination attachment. This equipment has been in continuous use.

(vi) *Phase Loss Studies.*—Investigations are proceeding to identify and distinguish between the contributions to the phase loss made by the nature of the material of the surface and the surface structure of the surface.

(vii) *Liquid Surface Interferometry.*—Attempts are being made to extend the use of liquid surface interferometry to multiple-beam systems. To do this a mercury surface is being used as an absolute reference of flatness and multiple-beam interference fringes between the surface and a silvered optical flat have been observed showing very little vibration. Further anti-vibration precautions are being tried to remove the vibration completely. The Lumner-Gehrcke interferometer principle has also been used to obtain multiple-beam interference between a liquid surface and an opaque surface. A method of measuring surface tension of liquids is being investigated.

(viii) *Adhesive Films between Metal Surfaces.*—The work on the nature of the so-called wringing films that enter into all aspects of length metrology has progressed in some degree, though depletion and shortage of staff have delayed activities. Equipment has been set up to attempt to obtain definite measuremen of the contact error that arises in wringing by usin multiple-beam interference. Experimental wor already done by electrical and multiple-beam inter ference methods indicates that there is not necessaril a definite film thickness between surfaces in wringin contact.

(ix) *Graticule Production.*—A series of graticul have been produced by the double evaporation of zi and chromium and of aluminium and chromium whi give fine durable lines of chromium on glass.

(x) *Wavelength Data and Correction Tables f Interferometry.*—A comprehensive series of tables ha been compiled giving all the necessary wavelength a refractive index data and correction factors that ha to be used in reducing results in length interferometr The tables cover the wavelengths of cadmium, krypto and mercury 198.

(xi) *Photoelectric Setting Device.*—A photoelectr setting device described recently in an overseas journ for making accurate settings on interference fringes spectrum lines has been built up in experimental for The setting accuracy is of the order of 0.2 μ (0.000 inch). With ruled lines on opaque surfaces the setti accuracy is 0.1 μ.

(xii) *Excitation of Gas Discharge Lamps.*—Develo mental work on the v.h.f. exciter for mercury 1 isotope electrodeless lamps has been carried to an a vanced stage. A power output of 130 W. into resistive load has been measured at 193 Mc/s., a satisfactory operation of the lamp, both with and wi out water cooling, has been obtained. It has be found possible to initiate the discharge in the la without the aid of auxiliary apparatus and the desi is such that misadjustment of the lamp circuit can cause damage to the radio-frequency power amplifyi valves.

A simplified exciter, which is operated from t 50 c/s a.c. main, has been developed for the mercu 198 cold cathode discharge lamp.

A study of the operation of krypton and mercu 198 discharge lamps with inductive stabilizing imp ances at an operating frequency of 50 c/s has be made.

(xiii) *Test Work, Assistance, Advice, and Exhibi* —A small amount of test work has been done a assistance and advice given to Universities, indust and other Divisions and Sections of the Organizati

(*g*) *Capacitance Displacement Meter.*—Displa ment meter type B is nearing completion. This instr ment is a compact development from the earlier equ ment, type A. The stability of the type B meter co pares favorably with that of type A.

It has been concluded from this developmental p gramme that the stability of frequency-shift displa ment meters depends principally on the frequen stability of the oscillatory circuits. Temperature c trol of the oscillatory circuits has been found to suf from two disadvantages, (i) a considerable time required for the isothermal enclosures to reach therm stabilization, and (ii) after the controlled temperatu of the oscillatory circuits has become constant, a c tinuous drift in frequency is observed. This frequen drift, which is of the order + 5 p.p.m./hr. in frequen is thought to be due to mechanical instability of t components of the oscillatory circuit under conditi of elevated temperature (50° C.). In the present d placement meter two similar oscillatory circuits a employed. A practical compromise has been obtain by equalizing the frequency sensitivity with respect change in temperature of these two tuned circuits a arranging that both suffer approximately the sa change in temperature.

he development of a recorder-amplifier is nearing pletion. This unit will enable the capacitance dis- ement meter or any other source of voltage with output of the order 100 mV from a high resistance e used in conjunction with an ordinary recording liammeter. It is hoped to produce a stability of er reading comparable with that of the displacement er.

h) *Abrasives and Lapping.*—The most important ject completed was the production of a set of end ndards for use in a series of international intercom- isons.

ome work has been done on the development of hniques for producing surfaces of suitable quality ruling the high grade line standards.

i) *Photogrammetry.*—The permanent equipment talled for the calibration of aerial cameras was put o service during the year and has proved quite satis- tory.

Measurements have been made of the effect of using ious filters on the principal distance and distortion a camera lens.

j) *Measuring and Consultative Service.*—There has n no diminution in the volume of work submitted the Division for examination and calibration, nor the inquiries concerning problems relating to precise asurement. Some items of interest in this work are follows: (i) The shafts of a large acetylator vessel re aligned on behalf of a commercial organization.) An investigation was made of a damaged aircraft pellor assembly. (iii) A machine has been designed d constructed for the production and examination standard templets used in the calibration of leather- asuring machines. (iv) A co-ordinate measuring chine used by the Commonwealth Observatory has n reconditioned and modified and its accuracy con- erably improved.

Items of equipment submitted for test include sets slip gauges, combination end bars, limit gauges of types, surface finish specimens, lathes, and a wide riety of measuring instruments and other equipment.

Several items of equipment have been designed and nufactured for use within the Division including a velling microscope having co-ordinate movements of nches and 1 inch, a 20-in. sine-table for the accurate neration of small angles, and an apparatus for use testing dial gauges.

3. Mass and Associated Quantities.

(Division of Metrology.)

(a) *Standards of Mass.*—The work on the metric ndards of mass has been continued and a number s been finished. The final polishing and adjustment nominal mass has been performed simultaneously by use of electrolytic polishing.

The design has been completed of equipment for erchanging the weights on the pans of a balance thout having to open the balance case. The pro- ion of this equipment will enable the conditions side the balance case to be kept very steady during intercomparison.

(b) *Investgations on Balances.*—The 100-kg. balance ich was rebuilt has been thoroughly tested out and performance found to be entirely satisfactory up to load of about 80 kg. Above this load there appears be a slight instability of the rest point reading. It satisfactory to record that the sensitivity-load rela- nship determined experimentally agrees well with at deduced from measurements of the dimensions and stic properties of the beam.

(c) *Density Measurement.*—A considerable volume of work has been done with this equipment on the determination of the densities of solids and liquids and in the calibration of hydrometers, and results obtained over a period of several months show excellent agreement.

(d) *Barometry and Pressure Measurement.*—The long-range gauge barometer based on a National Physical Laboratory design is very nearly completed. Equipment for the purification of mercury has been made and is in course of assembly. The design has been completed of a pressure-vacuum vessel for the calibration of mercury barometers.

4. Applied Mechanics.

(Division of Metrology.)

Liaison with the engineering industry has been further strengthened throughout the year. An example of this is the active assistance given to the Sydney Section of the Institution of Production Engineers in an industrial investigation necessitating the co-operation of a large number of engineering firms in New South Wales. The project involved an analysis of existing design practices in engineering. The response from the firms was very satisfactory. As a result of this analysis, evidence now exists to point the way in which considerable economies in engineering production might be achieved in industry. Alongside these developments in industrial research must be placed demands from industry for advice and assistance on all sorts of vibration problems. Such demands have been heavy enough for the Division to survey existing technical facilities and to collect and collate modern technical knowledge on vibration isolation.

(a) *Machining.*—During the year an officer of the Section toured parts of Europe and the United States of America with the object of studying modern overseas developments in machining research. Machining research and other allied topics were discussed with most of the well-known production engineering research workers in the world. Information obtained on this world tour is now being used in the Division as a basis for establishing research programmes in machining and for selecting the most suitable equipment.

The first project on machining research undertaken consisted of a review of some overseas developments in surface finish with reference to the effect of finish on function as well as the factors affecting finish in machining. A review is now in hand of the specifications for surface finish prepared by the international standardizing bodies of various countries.

Work is proceeding on methods of defining and measuring sharpness of the edges of cutting tools.

An investigation was made into a suitable method for comparing the cutting performance of Swiss needle files. Some difficulties were experienced in developing a satisfactory test based on workshop conditions, but finally a compromise solution was adopted and a commercial filing machine was successfully adapted for the purpose.

The nucleus of equipment required for machining research is now being installed.

(b) *Engineering Design Analysis.*—Whilst on tour in Europe the officer mentioned above accepted an invitation from the Institut Supérieur des Matériaux et de la Construction Mécanique to describe the Division's work on engineering design analysis. Officers of the Division have taken a leading part throughout the year in a project of a working group which was established by the Sydney Section of the Institution of Production Engineers to analyse design and drawing practices in New South Wales. This group was formed following the analysis carried out by the Division in connexion with the 1951 Engineering Production Convention. This analysis revealed that considerable economies might be achieved in the engineering industry by a proper analysis in design and intelligent use of a common series of basic engineering standards. The group established by the Institution adopted the techniques developed by the Division, including the "design problem technique" for conducting the analysis and applied these techniques in a similar manner but on a wider basis. The group's analysis confirmed the finding that considerable economies could be achieved in engineering by the adoption of the rational design methods and practices recommended by the Division.

Investigations are proceeding on a programme of research aimed at determining accurately the tolerances appropriate to particular manufacturing processes. This research work will be done partly in the Laboratory and partly in industry.

(*c*) *Vibration Measurement.*—The development of a technique for the calibration of sensitive vibrometers by multiple-beam interferometry has concluded. Arising out of this work a short paper has also been published, describing an adjustable mount using differential screws, which has been used successfully for the fine adjustment of interferometer plates and electrical capacitance plates.

The investigation of the characteristics of two types of self-generating vibration pick-ups developed within the Division has now been concluded.

Assistance has been given to industry in a number of vibration measurements. Once more, the demands from industry have pointed to the need for adequate permanent facilities for the calibration of vibration measuring instruments.

(*d*) *Vibration Isolation.*—Work is proceeding on the preparation of a survey of existing knowledge on vibration isolation.

Some preliminary investigations have been made to determine the level of vibration within the Laboratory building, particularly with the object of identifying the sources of vibration and arranging for isolation mountings where necessary.

(*e*) *Measurement of Physical Quantities for Industry.*—(i) *Force*—Negotiations have continued for the provision of a 50-ton dead-weight testing machine for the calibration of proving devices. In order to extend the existing range of proving equipment a 1-ton proving ring is under construction, and a 25-ton ring is also being designed. A table of gravity correction factors has been prepared for reference in making this type of adjustment.

(ii) *Pressure.*—In the verification of the piston-type of pressure-gauge tester, which is used for the precise determination of pressure, it is necessary to determine accurately the effective hydraulic area of the piston/cylinder element. This is particularly necessary for high pressure, small diameter units. Work is now proceeding on the development of a numerical procedure for this purpose which will take into account the measured errors in the profiles of the piston and cylinder.

(iii) *Hardness.*—Work has continued on the improvement of methods for the complete verification of hardness testing machines, which involves checking the accuracy of the applied load and of the device for measuring the indentation. Various methods of measuring the indentor load are being investigated including the use of mechanical levers and diaphragm-type capacitance transducers. A technique has also been developed for verifying the depth indicators of Rockwell hardness machines, and a paper describing
the technique has been submitted for publication. I
practice it is often sufficient to use hardness te
blocks to check the overall performance of the
machines, and the calibration of such test blocks is mo
accurately accomplished by the use of a dead-weig
hardness testing machine. One such machine,
N.P.L. design, is being constructed and installed at t
Laboratory. Similar attention is being given to t
determination of indenter force and depth of penetr
tion in the case of rubber hardness testers.

(*f*) *Verification of Materials Testing Machines a*
Equipment for Industry.—The examination
materials testing machines in New South Wales a
Queensland has continued on behalf of the Nation
Association of Testing Authorities and the Servic
Inspection Authorities, and at the request of priva
firms. In addition, many types of portable engineeri
instruments and equipment have been received a
calibrated at the Laboratory.

(*g*) *Survey of Dynamometers.*—Frequent inquiri
are received from industry for the dynamometer pow
testing of engines, tractors, and the like. On behalf
the Engineering Group Committee of the C.S.I.R.
and the Department of Supply, an Australia-wi
survey has been made of the facilities available f
such work. This survey has been completed.

(*h*) *Information and Assistance to Industry a*
Other Organizations.—Information has been given
such subjects as the design and construction of provi
rings; force applied by a screw; spring testing; rati
of power presses; performance testing of fans a
internal combustion engines; pressure measureme
and the construction of pressure gauges; weighi
devices for meat dehydration investigations; physic
testing of rubber; retardation testing of elevator
calibration of instrument springs; materials testi
machines; relation of surface finish to work proces
cutters used in steel wool manufacture; testing of
torque convertor; hardness number conversions; stre
in a propeller shaft of a ferry; performance testing
petrol engines; applications of stroboscopes; dynam
balancing principles and techniques; vibration isol
tion of galvanometers, compressors, machine tools, a
balances; nature of vibration associated with vario
types of industrial equipment; apparatus and tec
nique for vibration measurement and for the calibr
tion of vibrometers; theory of automatic dynami
balancing devices; design of fan brake for testi
engines; reduction of vibration in electric
machinery.

Assistance has been given by undertaking speci
test work, including the calibration *in situ* of
electromagnetic vibrator in the range 0.060 inch
20 c/s to 0.00001 inch at 6000 c/s; headstock vibr
tion measurements on an industrial lathe; vibrati
measurements to determine the best position for se
sitive apparatus; measurements of the vibration d
to a large forging hammer; calibration of a strob
scope; screwdriver torque tests to determine the hol
ing strength of screws in domestic electrical fittin
and the torque that can be applied manually by
screwdriver; flexure tests on glass rods; pressu
tests on bursting disks.

XXV. PHYSICS.

1. General.

The Organization is engaging in many aspects
physical research within a number of Divisions a
Sections. The present Chapter is concerned with t
work of the Division of Physics, which forms part
the National Standards Laboratory.

Division of Physics.—The Division is responsible for intaining the Commonwealth standards of measure-nt of heat, light, and other closely related physical antities, and also the primary standards of resistance d voltage.

Assistance has been given as in the past to industry, vernment and University Departments and to other visions of the Organization on a wide variety of oblems. One investigation which merits mention was dertaken in connexion with the Snowy Mountains ydro-electric scheme. This involved finding a rapid ethod for determining rather accurately the moisture ntent of soil to be used as filling in the construction the Eucombene dam. Progress in this problem has en facilitated by the secondment from the New South ales Department of Works of an officer to work under e direction of the Officer-in-charge of the Heat ction.

Officers of the Division contributed materially to the ork of the Standards Association of Australia, the ustralian National Committee on Illumination, the ational Association of Testing Authorities, and the ptical Munitions Technical Advisory Committee of e Department of Supply. The Division has also dertaken work on rain precipitation in collaboration ith the Division of Radiophysics. This work is re-rted in Chapter XXVIII., Section 8.

The Division's work on solar physics is described in hapter XXIX., Section 2.

2. HEAT.

(Division of Physics.)

The main fields of research and investigational work e concerned with phase nucleation, low-temperature ysics, and temperature measurement. The most gnificant development has been in low-temperature ysics where the experimental programme has com-enced with the examination of the thermal conduc-vities of various metals.

At the invitation of the International Bureau of eights and Measures tentative arrangements have een made for the Laboratory to participate in an ternational intercomparison of that portion of the nternational Temperature Scale maintained by ference to resistance thermometers.

(*a*) *Measurement and Control of Temperature.*— i) *International Temperature Scale.*—Improvements ave been effected in some of the technical procedures volved in maintaining the International Tempera-ure Scale. For example, platinum resistance thermo-eters of improved stability have been constructed, iple point of water cells has been brought into egular use as an alternative to the ice point, and n examination has been commenced of the repro-ucibility of the temperature obtained by the use of the atter fixed point. Work is proceeding on the develop-ent of equipment for the control and precise measure-ent of the pressure in apparatus for realizing boiling-oint temperatures defined on the International Tem-erature Scale. To facilitate the calibration of stan-ard thermocouples, automatic control of the elting-point furnaces and automatic recording of the elting-point temperatures have been installed.

To check the maintenance of the International Tem-erature scale in the optical pyrometer region, arrange-ents are in hand for an intercomparison of the tem-erature scale above 1063° C. maintained at this aboratory and at the National Physical Laboratory, ngland.

(ii) *Thermoelectric Effects due to Strain.*—The in-estigation of the thermal e.m.f.'s produced by longi-udinal strain in otherwise homogeneous wire when placed in a temperature gradient has been continued. The results obtained with eleven different metals are in general agreement with and considerably extend previous investigations of this phenomenon.

(iii) *Pyrometry.*—In addition to the calibration of pyrometric equipment, numerous requests for advice on temperature-measurement problems have been made by industrial and scientific establishments. As in past years, a formal course of instruction in temperature measurement was given to industrial personnel. An automatic 25-point selector switch with very small parasitic e.m.f.'s, and a reversing switch in which the thermal e.m.f.'s are less than $0.01\mu v.$, have been constructed for use in thermocouple circuits.

(*b*) *Hygrometry.*—Although the psychrometric method of measuring relative humidity is capable of high precision, the theory of the behaviour of a wet element in a moving air stream is not sufficiently well developed to permit of the wet bulb temperature being regarded as other than empirically related to relative humidity. Such a criticism does not apply to the temperature of adiabatic saturation of air, and several experimental arrangements were developed with which this temperature could be realized. It was concluded, however, that an instrument designed on these principles would lack versatility and convenience and would, therefore, not provide a sufficiently useful tool to justify its development. As a more convenient covering than cotton for the wet element when fine thermocouples are used as psychrometric elements for the measurement of relative humidity, it has been shown that gelatin film is quite satisfactory if suitable precautions are taken to ensure its wetness. An automatic photoelectric dew-point hygrometer designed to have rapid response is nearing completion.

(*c*) *Moisture Content.*—Recently the New South Wales Department of Public Works sought advice on the most suitable method for rapidly determining the moisture content of soils to be used in the construction of the Eucumbene earth-wall dam at Adaminaby, New South Wales, the requirements being that each measurement should be made in about 3 minutes to an accuracy of about ± 0.5 per cent. in moisture content on 1-lb. samples. In collaboration with the Department of Public Works a detailed investigation is almost completed of three promising methods in which measurements are made of, respectively, (i) soil density, (ii) pressure of gas generated by a reaction with the soil moisture, and (iii) loss of weight produced by rapid drying. Field trials will be made at the conclusion of the laboratory investigations.

(*d*) *Phase Nucleation.*—The process of the initiation or nucleation of one phase from another is of considerable practical importance, for instance, in the formation of bubbles in superheated liquids, the condensation of vapour on solid surfaces, crystallization, and the formation of ice in the atmosphere. Both theoretical and experimental work have been continued in this field, particular attention being given to the vapour-liquid change on solid surfaces and to the liquid-solid change in pure water.

The theoretical investigation by an officer of the Division of the condensation of vapour on a solid surface has shown that at very low supersaturations condensation must be attributed to imperfections of the surface. An experimental test of this theory is in progress and these investigations will, it is expected, provide information on other problems of phase nucleation.

(*e*) *Precipitation.*—Investigations on the sublimation of solid carbon dioxide in super-cooled fogs, the production of ice crystals by this process, and of the collision cross section of raindrops relative to mist droplets have been continued. These investigations are of relevance to the processes of artificial and natural production of rain, and are described in greater detail in Chapter XXVIII., Section 8.

(*f*) *Low-temperature Physics, Theoretical Research.*—The importance of experimental and theoretical researches on the properties of substances at very low temperatures has been commented on in previous Reports. Theoretical studies have been carried out during the year or are in progress on the following:—(1) The solution of the heat transport equation for pure metals. (2) The implications of the experimental results obtained in the Laboratory on the thermal conductivity of monovalent metals at low temperatures. (3) Heat transport processes in metals in the superconducting state. (4) The heat conductivity of dielectrics, including highly anisotropic substances such as graphite; this work has apparently resolved inconsistencies between the observed specific heat and the observed thermal conductivity of graphite. (5) The anomalous electrical and thermal resistance of certain metals at very low temperatures. (6) The electrical conductivity of cold-worked metals. (7) The theory of the electron gas in metals and semi-metals.

(*g*) *Low-temperature Physics, Experimental Research.*—(i) *Helium Liquefier.*—The liquid helium plant has operated very satisfactorily during the year and numerous improvements have been made, the main results of which have been: (1) Reduction of starting time to 1 hour. (2) Reduction of stripping down and reassembling time from 4 days to 1. (3) Economics in the use of liquid oxygen. (4) Improved liquid helium transfer facilities.

(ii) *Thermal Conductivity.*—To provide more information for theories of the electrical and thermal transport properties of solids, measurements in the range 2–200° K. have been made of the thermal conductivity of the monovalent metals gold, silver, and copper in various states of physical and chemical purity. Work has also commenced on certain binary alloys and on selenium.

(iii) *Electrical Conductivity.*—To test the validity over a wide temperature range of the Weidemann-Franz law of electrical and thermal conductivity a cryostat has been built for determinations of the electrical conductivity of metals suitable for the range 1–300° K.

(iv) *Specific Heats.*—The construction of equipment for the measurement of specific heats down to very low temperatures is well advanced.

3. LIGHT.

(Division of Physics.)

Research on the theory of optical instruments, in particular reflecting microscope objectives, has continued and considerable progress has been made in the construction of equipment for solar research.

(*a*) *Photometry.*—(i) *Photometric Standards.*—The variability of output and the apparent instability of photometric standard lamps is one of the serious difficulties of photometry. Receipt of a group of new standard lamps calibrated at the National Physical Laboratory, England, has given opportunity to study these uncertainties in some detail by intercomparison of the present outputs of the lamps with those found before despatch to Australia.

The conclusion is that some, at least, of the difficulty encountered with standard lamps arises from shock during transport. Some of the differences among the intensity standard lamps, however, are almost certainly due to the difficulty in re-establishing the precise alinement of the lamp, and it has been shown that in some cases the intensity varies by as much as 1 per cent for a change in orientation of 0.5°. Other causes o lamp variability are under investigation.

(ii) *Colour-temperature Photometer.*—A photoelectric flicker photometer has been designed and constructed for the precise measurement of colour temperature. With this instrument colour temperature are readily reproducible to an accuracy of 2° K.

(iii) *Spectrophotometry.*—Accurate spectrophotometry forms the basis of most photometry, and a larg precision double monochromator to be used for spectrophotometric standards has been completed, apar from the 6-in. prisms on which final figuring is now being done in the optical shop. This instrumen embodies several novel features.

An investigation of the errors in the intensity scal of the Division's automatic spectrophotometer an other spectrophotometers has been completed.

(iv) *Standards of Spectral Reflectance.*—To mee demands for reflectance standards in industry a grou of white "Vitrolite" glasses has been calibrated a standards with respect to the reflectance of a magnesium oxide surface. A number of magnesium samples of different origin have been used, and consistent results obtained to within 0.2 per cent. ove the range of the visual spectrum.

(v) *Photometry of Road Signs.*—During the revision of the Road Signs Code by the Standards Association of Australia, the need arose for a means of specifying the optical properties of reflectorized road-signs materials which are used to make signs visible to ca drivers at night. A portable photoelectric photometer incorporating an autocollimator, has been develope for this purpose, and has proved equally suitable fo testing road-sign reflector buttons.

(*b*) *Optics.*—(i) *Reflecting Microscopes.*—The optical properties of reflecting microscopes differ from those of lens systems in that there is always a centra obstruction in the light beam. The diffraction effects of this obstruction cause loss of image contrast. The magnitude of this has been investigated theoretically by an officer of the Division while holding a C.S.I.R.O. Studentship at the Institut d'Optique, Paris. As a result, precise tolerances can now be stated for th amount of obstruction permissible without causing a noticeable loss of image contrast. These tolerances cannot be satisfied by two-mirror objectives.

For comparison with theory, various types of objectives using three and four mirrors are being studied; the performance of these objectives should be equal to those of lens objectives.

(ii) *Definition in Optical Instruments.*—The performance of an optical instrument is never perfect, since aberrations are inevitably present. Quality of performance is usually judged by comparison with other instruments of the same type. Such a method leads to considerable variations in interpretation and demands considerable training on the part of the observer.

The theory, referred to in Section 3 (*b*) (i) above, worked out initially for reflecting microscopes, is also applicable to the testing of optical instruments in general, and suggests a line pattern having a sinusoidal variation in density as test object for measuring definition. There is considerable advantage in the direct measurement of image contrast which this method gives, since it avoids subjective errors in assessing definition. Two such systems are being constructed for the photoelectric measurement of contrast in microscope and telescope images.

iii) *Diffraction by Generalized Phase- and Ampli- -Changing Apertures.*—One of the principal con- utions to optics in recent years has been the study various places of diffraction effects produced by rtures which introduce phase or amplitude changes he transmitted light. One of the results has been development of the phase-contrast microscope, ther the hologram. The effect of phase changes pro- ed by striations in lenses may also be treated from point of view. Results of considerable interest e been obtained in the Division in theoretical studies uch phenomena.

c) *Solar Physics.*—An account of the Division's k in Solar Physics will be found under Extra- estrial Physics, Chapter XXIX., Section 2.

4. Electrical Standards.

(Division of Physics.)

he Division maintains the Commonwealth primary dards of electromotive force and resistance by ns of standard cells and resistors which are odically compared with the standards of the ional Physical Laboratory, England.

he maintenance of the volt by means of standard mium cells involves the periodical intercomparison large number of cells. A new procedure for this ess has been adopted which is considerably faster also more reliable than that used previously.

5. Electronics.

(Division of Physics.)

a) *Mass-spectrometer Leak Detector.*—The con- ction of a modified mass spectrometer for the ction of vacuum leaks has now been completed.

b) *Colour-filter Computer.*—The colour-filter com- er mentioned in last year's Report has been signed in order to avoid mechanical switching of electrical circuits; and a new instrument is under struction.

c) *Nuclear Magnetic Resonance.*—Apparatus is g set up to observe the phenomenon of "nuclear gnetic resonance", which occurs when a substance taining magnetic atomic nuclei is exposed to crossed gnetic fields, one being steady and the other oscillat- The phenomenon may be used to provide precise trol of magnetic fields as, for example, in mass trometers.

XXVI. ELECTROTECHNOLOGY.

1. General.

he electrical research of the Organization is under- en mainly within the Division of Electrotechnology, much electrical work, particularly in electronics, lso undertaken in other Divisions and Sections as integral part of research in other fields of estigation.

ivision of Electrotechnology.—As part of the tional Standards Laboratory, the Division is ponsible for the maintenance of the Common- lth standards of measurement of electrical quan- es other than the primary electrical standards— volt, the ampere, and the ohm. In addition to its earch on electrical measurements and standards, Division also undertakes research in electrotech- ogy. The Division has continued to give assistance advice to many inquirers from industry and else- ere, and members of the Division serve on advisory technical committees of the National Association Testing Authorities and of the Standards Associa- n of Australia. The Organization also collaborates h the Electricity Supply Association in encouraging electrical research within the Universities through its Electrical Research Board. Work of the Division of Electrotechnology is reported in Sections 2–8 of this Chapter, and that of the Electrical Research Board in Section 9.

2. Direct Current.

(Division of Electrotechnology.)

A 1 to 100 ohm "build-up" resistance box has been constructed and is being adjusted. By providing a precise 100 : 1 ratio it will facilitate the direct comparison of a 100-ohm resistor with a known 1-ohm resistor. It will also be of use in the measurement of standard resistors of other values. A 100 to 10,000 ohm "build-up" resistance box of similar design is also being made.

Apparatus for the measurement of direct currents greater than 5,000 A has been made and tested and an adjustable voltage source has been constructed for use in calibrating voltmeters.

3. Power Frequency.

(Division of Electrotechnology.)

There has been an increasing demand for calibration of current and voltage transformer testing sets. In order to speed up this work, equipment has been constructed to simulate an instrument transformer with "errors" which are adjusted by means of manually operated controls. Simple electrical circuits have been developed by means of which the conventional vibration galvanometer of a current transformer testing set may be replaced with a cathode-ray oscillograph detector.

4. Audio and Radio Frequency.

(Division of Electrotechnology.)

(*a*) *Impedance Measurements.*—Most of the methods that have been used for an absolute determination of the ohm have been based on the calculation of inductance from linear dimensions. An alternative method based on the calculation of capacitance involves a knowledge of the velocity of light. In recent years a number of determinations of the velocity of light have been made and the accuracy claimed is now better than the limit to which the ohm is believed to be known. A determination of the ohm based on capacitance would give valuable confirmation either of the ohm or the velocity of light. With capacitors the metrological measurements are simpler and the Laboratory has had considerable experience in the electrical measuring techniques. It is considered that these can be refined sufficiently to make the metrological measurements the limiting factor. A number of components has been developed for the measuring system proposed and good progress has been made with others. A new bridge method for the comparison of capacitance and resistance has been investigated and is capable of the precision required.

For use with a capacitance-type pressure gauge a capacitance bridge for the precise measurement of capacitance in the range of 100 to 10^{-4} pF. has been constructed. Another three-terminal capacitor designed for the measurement of very small currents from ionization gauges has been made with extremely high insulation resistance.

One limitation of a tuned amplifier for detecting a small signal in the presence of harmonics is the spurious fundamental produced by intermodulation of the harmonics. This effect has been investigated and an amplifier has been constructed in which the intermodulation is negligible for the harmonic levels associated with precise bridge measurements.

(*b*) *Dielectric Measurements.*—Measurement of the relative permittivity and loss of dielectrics can be made over a wide range of frequencies extending from 10^{-2} to 2.4×10^{10}c/s. Over most of this range of frequencies measurements can be undertaken at any temperature between —80 and +70° C. and in some cases at temperatures approaching —190° C.

(*c*) *Frequency Measurement.*—To the original frequency standard, consisting of three quartz crystal oscillators, two more oscillators and associated beat counters for comparing their frequencies have been added. Investigations are being made of the effect of changes in room temperature on the frequency of the oscillators. The equipment for the precise measurement of frequencies above 100 Mc/s. has now reached the stage where marker signals, whose frequencies are known with great accuracy, may be generated at frequencies up to 35,000 Mc/s.

(*d*) *Noise Generators.*—Fundamental investigations at 200 and 3,000 Mc/s. of the electron velocities and random noise radiated from experimental neon discharge tubes over a range of gas pressures and discharge currents have been completed. Work at 3,000 Mc/s. on random noise generators for determining the absolute sensitivity of radio receivers has been directed mainly towards improving the accuracy of measuring the power output from a black-body radiator of low but known uniform temperature, which is used as an absolute reference level.

(*e*) *Microwave Spectroscopy.*—Experience gained in the operation of the microwave spectroscope has led to modifications of the existing equipment and to the development of new apparatus. High frequency (105 kc/s.) sine-wave and square-wave Stark modulating systems have been employed. A programme of investigation into microwave spectra using the spectroscope has commenced.

(*f*) *Millimetre Wavelengths.*—Apparatus for the generation and detection of radio energy at a wavelength of about 8 mm. has been put into operation, and similar equipment for a wavelength of about 6 mm. is under construction.

5. MAGNETIC MEASUREMENTS.

(Division of Electrotechnology.)

In addition to routine calibration work, a good deal of effort has been put into the detailed checking of the measuring instruments and equipment used in magnetic testing. Assistance has been given to another Division in the design of an electromagnet, and to a manufacturer of electric motors in the development of a rapid production tester for stator laminations.

6. DIELECTRIC INVESTIGATIONS.

(Division of Electrotechnology.)

Work has been continued on the relationship between the chemical and physical structure of organic compounds and their dielectric properties. All the measurements on solids in previous years have been carried out on polycrystalline material. Some measurements have now been made on single crystals, in the course of investigations on clathrate compounds.

(*a*) *Theoretical Work.*—Consideration has been given to the much discussed problem of a satisfactory dielectric breakdown criterion and, while some hitherto puzzling features of breakdown can be explained by the ideas of various authors, an adequate description of the phenomenon has not yet been given. The present experimental work on the influence of electrode material on the apparent breakdown strength of a dielectric is also inadequate for forming definite conclusions.

(*b*) *Dielectric Properties of Mixtures.*—This work has been concluded and the results are to be published.

(*c*) *Dielectric Absorption on Hydroxy-compounds.*- The investigation of dielectric loss in hydrogen-bonde compounds is being continued. In order to obtai more information on the mechanisms leading to th type of loss, measurements are being made with mi tures and compounds containing hydrogen-bond chai of only two or three hydroxyl groups. In conjunctio with this work, the same materials are being subjecte to infra-red measurements at the Division of Industri Chemistry.

(*d*) *Clathrate Compounds.*—Some clathrate (cag like) compounds have been investigated more full Measurements on these compounds have yielded info mation about the energy barrier opposing rotation the small molecules entrapped in the parent cryst lattice and as to the axes about which rotation possible.

(*e*) *Combined Investigation of Dielectric a Thermal Properties.*—Many chemical compounds ex in different crystalline phases which are stable different temperatures. In work on the dielectric pr perties of such materials it is desirable to obta parallel information on their thermal behaviour. facilitate this work, apparatus has been set up to reco automatically the cooling curves of chemical co pounds. For this apparatus a commercial recordi potentiometer has been modified to record tempe tures, in the range of —50 to 105° C., to with ±0.05° C. The dielectric properties of a number long-chain acetates, in both α and β phases, have be investigated.

(*f*) *Protein Structure.*—An examination is bei made of the possibilities of using the dielectric pr perties of protein solutions in water to obtain inf mation about the size and shape of the prote molecules. This work is being done in association wi the Biochemistry Unit of the Wool Textile Resear Laboratories.

(*g*) *X-ray Crystallography.*—The study of t crystal structure of the secondary alcohol 14-hept cosanol, using a Weissenberg goniometer, is w advanced and has already yielded valuable informati on the likely causes of dielectric loss in this type compound.

7. SPECIAL INSTRUMENTS.

(Division of Electrotechnology.)

(*a*) *Temperature-salinity-depth Recorder.* — T design of an instrument to record the temperature a salinity of the ocean as a function of depth has be started. The instrument is required by the Divisi of Fisheries for oceanographic research (*see* Chapt XI., Section 4 (*j*)).

(*b*) *Straight-line Flight Indicator.*—In collabor tion with the Division of Radiophysics an instrume was developed several years ago for assisting t pilot of an aircraft fitted with a Shoran radar to fly along straight lines. This instrument has be modified to provide a number of different scales a also to plot the course of the aircraft and has be handed over to the Bureau of Mineral Resources f use in aerial survey work.

8. VACUUM ELECTRONICS.

(Division of Electrotechnology.)

The Division's work on electronic computation described in Chapter XXXI., Section 4.

9. ELECTRICAL RESEARCH BOARD.

The general objective of the Electrical Resear Board is the fostering of fundamental electrical resear in Universities and the training of graduates in resea methods. Grants are made for projects suggested the Universities.

The Board is representative of the Electricity pply Association of Australia, the Universities, and Organization. Financial support from member anizations of the Electricity Supply Association has abled the Board to support investigations in most the Universities of Australia.

Stability of power supply systems is being inves- ated in the University of Adelaide with simulating tworks and in the University of Melbourne by a del machine technique. Transients are being studied the University of Tasmania. In the University of eensland the programme on the protection of elec- cal plant against lightning is being continued with ld studies and the development of laboratory equip- nt for impulse testing. The University of Sydney s commenced work on the fundamental properties of miconductors. In collaboration with the supply thorities the University of Western Australia is termining the operating characteristics of steel con- ctors for rural distribution lines.

XXVII. RADIOPHYSICS.

1. GENERAL.

Research and developmental work on radar for the rvices was commenced in Australia during the cond World War with the establishment of the ivision of Radiophysics in Sydney. With the return peace-time conditions the Division's efforts were nsferred to fundamental research in radio and dar. The Organization has also continued radio search in collaboration with the Services, the Post- aster-General's Department and the Universities der the direction of its Radio Research Board. ring the year a Consultative Committee on Radio search has been established to facilitate liaison tween the various bodies carrying out research in the dio field and those who make use of the research.

In August, 1952, the International Union of Scienti- Radio (U.R.S.I.) held its 10th General Assembly Sydney. This was the first occasion on which any ternational scientific union had held a meeting in e southern hemisphere, and was an indication of the terest of world radio science in Australian researches this field. This Assembly was generally considered be one of the most successful and best organized con- rences yet held by the Union. The staffs of the ivision of Radiophysics and of the Radio Research ard contributed substantially to the successful ganization of the meeting, and made considerable ientific contributions to its deliberations.

Division of Radiophysics.—The Division is carrying t fundamental research in rain physics and radio tronomy, while, on the applied side, investigations nnected with electronic computing and radio aids navigation are proceeding. The Division's work rain physics and radio astronomy is now well estab- hed internationally, as witnessed by the selection of dney by the International Union of Scientific Radio r its General Assembly in August and the invitation the Chief of the Division to visit the United States America to advise on the establishment of a research ogramme on cloud and rain physics to be undertaken the University of Arizona.

The work of the Division is outlined in Sections and 7 (*b*) of this Chapter, Sections 9 and 10 of hapter XXVIII., Section 3 of Chapter XXIX., and ction 3 of Chapter XXXI.

Radio Research Board.—The Board has continued policy of concentrating the efforts of its staff on a w fundamental problems and at the same time foster- g and assisting complementary investigations in the Universities. The Board's full-time staff has been located at the Electrical Engineering Department, University of Sydney, and at the Commonwealth Observatory, Mount Stromlo. Approved projects have also been supported at the Universities of Queensland, Tasmania, and Adelaide.

Close co-operation exists between the Board's staff and that of the Ionospheric Prediction Service of the Department of the Interior. During the year the Board's staff has handed over to the latter the detailed results of its studies of the morphology of ionospheric storms.

As Japan was not represented at the General Assembly of U.R.S.I. the Japanese National Committee of Radio Science invited the Board's Chief Scientific Officer to visit Japan for three weeks in May, 1953, when he outlined to radio scientists the proceedings of the Assembly.

The work of the Board is outlined in Section 7 (*a*) of this Chapter.

2. RADIO AIDS TO NAVIGATION.

(Division of Radiophysics.)

There is considerable interest in the application of radio techniques to the navigation of aircraft over distances of 1,000 miles or so. On long ocean flights landmarks are few and it is necessary to rely on celestial navigation and dead-reckoning, supplemented, where possible, by medium-range radio "fixes" from islands or weather ships. None of the long-range radio aids at present in use are entirely satisfactory for the navigation of civil aircraft, because simple, automatic presentation of the information is lacking. Following the successful development of the short-range Distance Measuring Equipment (D.M.E.) by the Division, it was decided to explore the possibility of extending the method of long-range navigation. Details of this work and of another project are given below:

(*a*) *Long-range Navigation by Distance Measurement.*—Radio propagation round the curve of the Earth is only possible with low-frequency ground waves or with high-frequency sky waves reflected by the ionosphere. To investigate the reliability of the latter method, a radar-type beacon has been installed at Townsville, Queensland, and is triggered by pulses radiated from Camden, New South Wales. Multiple reply pulses, corresponding to the various paths through the ionosphere, are received at Camden from the beacon and are photographically recorded. The interpretation of these records in terms of ionospheric structure is assisted by comparison with other data obtained regularly by the Radio Research Board in Brisbane, which is near the mid-point of the 1,100-mile Camden-Townsville circuit.

The number, length, and absorption of the ionospheric paths vary diurnally and seasonally. Those paths due to reflection by the lowest ionospheric layer (the E layer) are the most stable in length and are most likely to be of value for distance measurement. At the frequency of the present experiments (9.8 Mc/s.), signals via these paths can be received throughout the day. During the night, reception is often patchy, even with high power, and appears to correlate with sporadic E ionization over Brisbane. A practical navigation system would require a number of channels and it is therefore proposed to extend the present measurements to a lower frequency. A conventional-type D.M.E. would need an aircraft transmitter of great power, and an alternative technique of distance measurement requiring only receiving equipment in the aircraft has therefore been proposed. A transmitter is located at each end of the flight path, and the distance measurement is most accurate on the great circle path between the two points. The method is therefore suitable for well-established routes.

Apart from their application to the navigational problem, the present experiments should add to fundamental knowledge of the ionosphere and are of considerable interest in connexion with communication service forecasts. Investigations of this type include the study of absorption and the accuracy of maximum usable frequency predictions.

(*b*) *Homing Glider.*—A recoverable glider for use in high-altitude research has been designed in co-operation with the Aeronautics Department of the University of Sydney. The weight is 12 lb., including a payload of 2 lb., and it is intended to be carried to a predetermined altitude by means of a balloon and then released. Signals from a ground beacon automatically actuate the rudder so that the model always glides towards the ground station. The first models should shortly be ready for flight testing.

3. MATHEMATICAL COMPUTATION.

(Division of Radiophysics.)

The Division's work on mathematical computation is reported in Chapter XXXI., Section 3.

4. CLOUD AND RAIN PHYSICS.

(Division of Radiophysics.)

This work of the Division is reported in Chapter XXVIII., Section 9.

5. RADIO ASTRONOMY.

(Division of Radiophysics.)

The work of the Division on radio astronomy is reported in Chapter XXIX., Section 3.

6. WIND MEASUREMENTS AT GREAT HEIGHTS.

(Division of Radiophysics.)

This work by the Division is reported in Chapter XXVIII., Section 10.

7. THE IONOSPHERE.

All long-distance radio propagation takes place through the ionosphere. The normal ionosphere is maintained in its ionized condition by radiation from the Sun and it therefore shows daily and seasonal variations. These are now reasonably well known for most regions of the Earth. Less is known about the abnormalities, such as ionospheric storms, which disrupt radio communications from time to time, particularly when sunspots are active on the visible solar disk. The most common method used for studying the properties of the ionosphere involves reflection of radio signals. An alternative method consists of making use of radiation from cosmic radio sources and determining the effect produced by the ionosphere on this radiation as it passes through the Earth's atmosphere. These effects may change with time either slowly or rapidly.

(*a*) *Investigations by the Radio Research Board.*—(i) *Ionospheric Winds.*—The Board pioneered the investigation by radio means of movements of ionization in the upper atmosphere some 200 miles above the Earth, and much information has now been obtained. Besides affecting radio propagation, these movements are important in upper atmosphere meteorology, and possibly also in high-altitude flight.

It has now been established that these movements have regular seasonal and diurnal changes of direction. Till recently observations have been confined to the daytime, but with recent improvements in equipment, it has become possible to study night-time conditions. Most of the observations so far have been confined to heights of about 200 miles. However, with the aid of a new variable-frequency recorder, designed and built by the Board's staff, the observing range has been extended both upwards and downwards. Recordings of travelling disturbances have led to a comparatively simple explanation of irregularities as due to "kinks" in the ionosphere. The elucidation of these phenomena permits the derivation of information on disturbances from recordings which have been made regularly in many parts of the world over the last ten years, thus providing a world-wide picture of upper atmosphere movements.

This information has permitted checking of certain theoretical deductions about the mechanism of radio wave propagation. For example, it has been known for some years that a radio ray travelling upwards is split into two rays in the ionosphere, and it has been deduced that these rays diverge and are reflected at differen points. From the study of travelling disturbances i has been possible to confirm this and to measure the separation of the reflection points.

(ii) *Electrical Conductivity.*—The theory of the abnormal conductivity of the ionosphere has now been thoroughly worked out, in collaboration with Dr. W. G Baker of Amalgamated Wireless (Australasia) Ltd. I has also been extended to derive the drift velocities o ionization at all levels in the ionosphere, and at all latitudes, under the influence of either winds or electric fields. In the course of this work it has been found tha the movement of ionization is unstable at heights nea 100 km., where a uniform ionosphere must break up into clouds or patches of irregular density. It is believed that this somewhat accidental discovery has revealed the reason for the occurrence of sporadic E ionization (E_s) at heights of about 100 km. E_s is responsible for much anomalous long-distance propagation of radio waves and is at present being studied extensively in the United States of America as a possible practical means o ensuring continuous radio communication at all times

(iii) *Ionospheric Effect of Magnetic Storms.*—Thi work has been extended, and the theory developed in detail. It is believed that it is now at a stage where i can be used by communications authorities to minimize traffic interruption. The Board's Chief Scientifi Officer has been appointed Chairman of a Sub-commission of U.R.S.I. charged with the task of preparing special report on the subject for the U.R.S.I. Assembly in 1954.

(iv) *Other Investigations.*—The Board is also investigating the theory of magnetic storms, and of the polar aurora, whose causations are still imperfectly understood. It has also commenced study of the non polar aurora (air-glow) which appears to emanate from the ionosphere.

(*b*) *Investigations by the Division of Radiophysics* —(i) *Twinkling of Radio Stars.*—Just as irregularitie in the lower atmosphere of the Earth cause twinkling of visible stars, so irregularities in the upper ionized atmosphere cause rapid changes or twinkling of "radio stars". This fact has been used to provide information about the ionospheric irregularities. Recently, the method has been extended by use of the radio spectrometer. Instead of a study of effects at a narrow isolated part of the spectrum, measurements over a wide range of frequencies can now be undertaken.

(ii) *Adsorption by the Ionosphere.*—Slow changes in the intensity of radiation from cosmic sources have been studied at the comparatively long wavelength of 16 m The calculated absorption produced by the lower layer of the ionosphere has been found to agree with results obtained by the reflection method. For the higher layers, however, the two methods give conflicting results It is thought that the resolution of this disagreemen l lead to a better knowledge of the ionosphere, ecially when similar measurements are made in other ts of the world.

(iii) *Investigations by Reflected Signals.*—Work ried out earlier on measurements of the temperature the lower layers of the ionosphere has led to an estigation of this region by reflection techniques. e region is of particular interest because it is largely ponsible for the attenuation of short-wave radio nals.

The new work differs from that of other observers in t very much weaker reflections can be detected. As a ult, the first clear demonstration was given of the stence of a distinct layer or layers at a height of km. above the surface of the earth. During the urse of the work, a new method was devised for ermining electron density and collision frequency in ionosphere. It is expected that this technique will d more general application in ionospheric work.

XXVIII. ATMOSPHERIC PHYSICS.

1. GENERAL.

Although for many years systematic meteorologists ve studied the day-to-day changes in Australian ather, studies of the fundamental phenomena underng these changes have rarely been undertaken. The ganization has embarked on intensive studies of the ysics of the atmosphere, as only through a knowledge the basic physical phenomena can radical new velopments emerge. Work on dynamical meteorology, neral circulation, heat balance, and micrometeorology being carried out within the Section of Meteorologi- Physics at Highett and Aspendale, Victoria (*see* ctions 2–7 of this Chapter). Arising out of studies the propagation of very short radio waves, the vision of Radiophysics has been working on the ysics of rain and cloud formation (*see* Section 9 of s Chapter). The Division of Radiophysics has also rked on the measurement of wind velocities at high itudes (*see* Section 10 of this Chapter). The vision of Physics at the National Standards boratory has also undertaken work on rain precipitan in collaboration with the Division of Radiophysics *e* Section 8 of this Chapter). Statistical analysis rainfall records is made by the Section of Mathemati- l Statistics, Adelaide (*see* Section 11 of this apter).

Section of Meteorological Physics.—The Section has programme of study whose main object is to attain more fundamental understanding of the weather and the physical processes which control it. Meteorology a public utility on which almost every phase of mmunity life depends in some way. Whereas teorology already provides a wide range of services the country, these can only prosper and improve ainst a background of basic research into the many oblems as yet unsolved. Thus, while some of the lds under investigation in the Section are capable of plication to the immediate benefit of the community, e main task is to consolidate the foundations of the bject, to strengthen it against the continually grow- g demands for meteorological information and advice ich are made by aviation and other transport ser- ces, by primary and secondary industry, and by the dividual in his private life.

2. GENERAL CIRCULATION.

(Section of Meteorological Physics.)

Work has continued on the study of the large-scale ansport of heat, water, and momentum by the variable r currents extending through the atmosphere from the rface to about 50,000 feet. These transports are major factors in determining the average pattern of wind, temperature, and rain over the whole earth, and the study may continue for many years so that not only the pattern and its variation with season, but also its variation from year to year, may be better understood.

The research involves the working-up of northern as well as southern hemisphere data, since the number of good observing points in the southern hemisphere is not sufficient to allow the problems to be tackled on the basis of these data alone. Parallel work is proceeding in many countries, much of it following the lines pioneered in Australia; the work is an example of international collaboration on an international scientific problem.

An exploratory study has been completed and published of another aspect of large-scale weather—the trends in temperature, rainfall, &c. which occur during periods of the order of a century. This has shown that, concurrent with the well-established and marked changes which have taken place in the northern hemisphere, particularly since about 1900, changes have also occurred over most of the south-east part of the Australian continent which may well fit into a consistent picture of global change. Inland summer temperatures have declined appreciably and summer rainfall in South Australia and Victoria has increased by amounts of the order of 20–50 per cent.

3. DYNAMIC METEOROLOGY.

(Section of Meteorological Physics.)

(*a*) *Large-scale Systems.*—The study of climatic features in Australia is largely concerned with the distribution of temperature and rainfall especially with regard to position relative to the coast and the eastern mountain ranges, and to latitude. The very marked changes in climatic conditions from place to place are broadly understood, although much work has still to be done in this field. Less is known concerning the occurrence of extraordinarily marked variations from year to year in some regions. These variations are shown up particularly in the areas subject to monsoonal seasons where a normally regular phenomenon may occur unduly late or even fail to appear, and their study calls for a physical approach rather than for the statistical methods normally used in climatology. A preliminary programme of research into three of the basic processes affecting these changes in Australia was set up early this year.

Most of the west and north-west of Australia in summer is dominated by a dry-monsoonal circulation, apparent as a surface low pressure area subject to diurnal oscillations. The intensity, position, and structure of this system are being investigated statistically. Relations to the large-scale features of the region, and in particular to the trade winds and to the northern wet-monsoonal circulation, are under examination.

Variations in the effective solar heating may be associated with the climatic anomalies in the region. A formula has been developed which allows the heat input to be calculated from suitably analysed charts, and the results are being studied on a continent-wide basis. Computations on similar thermally impressed patterns in other parts of the world are being made simultaneously.

Particular attention is now being given to the mutual dependence of the slow moving or nearly stationary large deformations and the smaller, more rapidly moving, disturbances which account for the typical weather sequences of Australia. Some aspects are being treated in collaboration with the Meteorological School at the University of Melbourne.

(*b*) *Convection.*—Work in recent years on the physics of rain has concentrated on the physical behaviour of cloud particles and drops, with relatively little research into the dynamical process of upward air movement or convection which provides the condition under which the drops can grow, and without which little rain can occur. A theory has now been developed for the motion and thermal behaviour of an element of air, of any size, moving under buoyancy in a turbulent environment.

4. MICROMETEOROLOGY.

(Section of Meteorological Physics.)

Micrometeorology is that branch of the subject concerned with the study of the physical processes that occur in the layer of air close to the ground. The three variables which control these processes are temperature, water vapour content, and wind structure, and measurement of these quantities with suitable instruments reveals in each case two outstanding features—

(*a*) A pronounced fluctuation in space and time. Instruments of the highest resolving power used to date fail to reveal a lower limit either to the period or dimension of these fluctuations, and the upper limit appears to be reached only at the scale of the largest weather systems.

(*b*) A marked stratification in the mean value of each quantity so that each may change rapidly with height in the lowest few feet. In general the nature of the change depends on the time of day, becoming reversed at night in the case of temperature and humidity, and its intensity depends on such factors as weather and type and condition of the soil and vegetation.

This complete structure has a profound influence on a wide range of superficially unlike phenomena, such as the warming of the atmosphere, the evaporation of water from land and sea, the frictional interaction between atmosphere and earth, the transport of light seeds, the dispersal of smoke from factories, &c. In particular the factors mentioned above determine the nature of the climate in and around crops, which, being subject to greater extremes, may be substantially different from that revealed by standard climatic data which refers to conditions at a height of four feet above a short grass surface.

From the meteorological aspect the importance of studying these processes lies in the fact that it is in this region that the exchanges of heat, water vapour, and momentum between the atmosphere and the underlying surface are effected. The energy of wind, rain, and heat in the atmosphere derive originally from these interactions.

The micrometeorological work so far carried out in the Section has been mainly of a fundamental nature, though the knowledge so gained has already found useful application in other connexions, for example, in the problem of frost prevention in orchards. The instrumentation designed for this investigation comprises apparatus of sufficiently rapid response to record the fine structure of temperature, humidity, and wind, and a mechanical analyser which, by providing correlations between the variables, yields values of the fluxes of heat, water vapour, and momentum. The fine-structure apparatus has recently been improved by the development of a hot-wire anemometer linear over the lower range of wind speed. So that account may be taken of all factors in the heat balance at the ground surface, instruments have also been designed to measure the net incoming radiation and the heat flow into the ground.

The field work at the experimental station at Edith
vale has mainly been an extension and consolidatio
of that of the previous year. To investigate the stru
ture of wind gusts in the lowest 500 feet of the atm
sphere, anemometers were designed and installed, i
co-operation with the Postmaster-General's Departmen
on a radio mast in open country near Sale. The purpos
was to provide designers of radio masts and other ta
structures with more reliable information on th
maximum wind pressure which may be encountere
Wind pressure calculations are at present based largel
on old observations of the variation of the *averag*
wind velocity with height and reliable measurements
the variation of *gust velocities* with height have bee
almost completely lacking. Sensitive recordin
anemometers, of rapid response, were installed
heights of 40, 210, and 500 feet above ground level an
records were obtained on 35 occasions of strong or ga
force wind during the period August-December, 195
Analysis of these records is now well advanced.

Another product of the work in micrometeorolog
is the development of fine probes capable of measurin
temperature and humidity, and fluctuations thereof, i
very small areas between the leaves &c. of trees an
other crops, where conditions may differ greatly fro
those outside.

5. FROST PREVENTION.

(Section of Meteorological Physics.)

Trials have continued on the protection of fruit fro
frost by means of fans, the action of which is to dra
air from heights of 40 or more feet above ground whe
the temperature on frosty nights is from 5 to 10°
warmer than near the surface. The object of the wo
is to determine the most efficient design of fan of a si
likely to be suited to Australian requirements.

The 1952 winter trials in citrus at Griffith (*s*
Chapter IV., Section 3) were made using a 12-
diameter airscrew of good aerodynamic design in pla
of the cruder 21-ft. rotor. The 12-ft. fan was found
give, with an axis tilt of 60° to the vertical, a perfor
ance equal to that of the larger 21-ft. fan used pr
viously on a vertical axis. The power consumpti
was the same in each case but the smaller fans ha
the advantage of being cheaper and more robust th
the large types.

A set of 60 electrical thermometers was provided a
a programme of observational work undertaken in co
nexion with a frost fan installed in a pineapple fie
in Queensland. The pineapple industry in Queensla
suffers, in some winters, losses due to frost damage
up to £500,000 and, owing to the high value per ac
of this crop, some method of frost protection may w
be economically sound.

The results obtained with the fan were, howeve
distinctly disappointing in comparison with those o
tained in citrus at Griffith with an exactly simil
machine. This was found to be largely a result of t
smaller increase of air temperature with height at t
Queensland site than at Griffith on clear calm nigh
To ascertain whether or not this is a result of the loc
topography, apparatus to record the temperature
various heights has now been installed at three pin
apple plantations some miles apart.

Work has recommenced this season at the Queensla
site in co-operation with the Queensland Departme
of Agriculture and Stock, on a series of trials compa
ing the effect of the frost fan with that of a layout
oil-burning orchard heaters of the type used in t
Mildura district to protect vines. Some trials will a
be made on a combination of the fan and a sm
number of heaters, a system now much favoured
California.

n addition to the work on frost fans, a large number bservations of the rate of loss of heat from the nd by radiation and of other factors bearing on incidence of frost were made at Griffith with the ct of providing improved aids to forecasting frost this irrigation area.

vailable instruments for frost alarm signals, em-ying mercury-in-glass thermometers with inset trol, have not proved completely reliable. Accord-y some consideration has been given to the suit-ity of other types. Tests with a simple bimetallic e of instrument have given promising results; these be continued.

6. Radio Meteorology.

(Section of Meteorological Physics.)

ome relationship might be expected between varia-s in conditions in the troposphere and in the osphere since both are due ultimately to solar in-nce, though the nature of the two influences are te different. Correlations which appear to have nite prognostic value to the meteorologists have n claimed to exist in different parts of the world similar relations, particularly beween parameters the tropopause and the F-layer critical frequency, e been sought in an investigation undertaken in the tion.

ustralian data have been limited to Canberra, where face pressure was used in the absence of tropopause a. A more extensive examination was made of data n south-east England. In Australia, though corre-on between critical frequency and sea-level pressure eared to exist, this occurred only at certain times nothing was found to provide a criterion for the urrence of such periods. In south-east England, in for certain periods only, there was evidence of relation of F-layer height with tropopause tempera-e, and of critical frequency with tropopause height; re was some indication that the occurrence of the mer was connected with wind conditions near the opause. A report is being prepared.

7. Minor Investigations.

(Section of Meteorological Physics.)

a) *Ozone Investigation.*—Measurements of the l concentration and vertical distribution of ozone he upper atmosphere have now been made for many rs at a number of stations in other countries, chiefly the northern hemisphere. The absorption of radia-n by ozone plays an important part in the radiative ilibrium of the atmosphere. Besides this, ozone iations appear to be closely associated with the optic situation and to provide an index of dynamic elopment in the upper atmosphere; their study is refore of potential value to the synoptic meteoro-ist.

t is proposed to make ozone studies in Australia h three ozone spectrophotometers which are present being recalibrated.

b) *Sea Surface Temperature Measurement.*—The ndard method of measurement of sea surface tem-ature by dip bucket is being checked by a radiation hod.

c) *Evaporation Survey.*—No further work on an poration survey has been done in the Section since task has been taken up by the Waite Institute, elaide.

d) *Wind Tunnel.*—A number of anemometers and meters were adjusted and calibrated for outside in-ests during the year.

8. Precipitation.

(Division of Physics.)

Investigations on the sublimation of solid carbon dioxide in super-cooled fogs and the production of ice crystals by this process and of the collision cross section of raindrops relative to mist droplets have been continued.

Experiments on surface accretion of ice on solid carbon dioxide pellets and on the effects of fog density on the sublimation rate of such pellets, together with direct measurements of the free water content of typical laboratory-produced fogs have been made. An analysis, making use of dimensionless parameters, of the results for carbon dioxide sublimation in moving air streams has led to a formula for representing the sublimation rate as a product of powers of the temperature difference, pellet mass, and air speed which satisfactorily represents the experimental results at all except very low air speeds. The results on the rate of sublimation of carbon dioxide provide the necessary information for the completion of the analysis of the experimental data on the production of ice crystals in super-cooled fogs by solid carbon dioxide.

9. Cloud and Rain Physics.

(Division of Radiophysics.)

This work is aimed at obtaining a thorough understanding of the physical processes which are involved in the formation of cloud and rain, and has the final objective of discovering whether it is practicable to influence the incidence and distribution of rainfall by artificial means. A wide range of investigations is being carried out, including work on the nature and origin of the microscopic nuclei on which water vapour condenses to form fog or cloud droplets, the air currents on which the nuclei rise and grow, the magnitude and distribution of the water droplets throughout the cloud, and the initiation of the freezing process at higher levels in the atmosphere. In addition, controlled experiments are made of the efficiency of various methods of producing artificial rain.

Much of this work is performed in aircraft specially equipped for the purpose and flown by a Detachment of the Royal Australian Air Force Aircraft Research and Development Unit. An accident, so far unexplained, which occurred during one of these research flights resulted in the complete loss of the aircraft together with its crew and two members of the staff of the Division. The loss of these two officers, together with the special equipment on the aircraft, resulted in a considerable setback to the work of the Division.

(*a*) *Condensation Nuclei.*—It is well known that condensation does not occur when perfectly pure air is cooled to the dew point temperature. Cloud and fog droplets must have some kind of condensation nuclei upon which to form. The free atmosphere contains these in relatively large numbers. The concentration of such nuclei may vary from a few hundred per cubic centimetre over the ocean to several hundred thousand per cubic centimetre in industrial areas. Little is known about the constitution of these particles, but they can be divided broadly into two classes—

(*a*) A number of comparatively large nuclei which consist of sea salt and have formed by the evaporation of spray droplets from the ocean.

(*b*) A comparatively numerous class of minute hygroscopic particles which have their origin over the land masses from dust and from the burning of fuels such as wood, coal and oil.

The smaller particles are important in the formation of the innumerable small droplets that make up fog and cloud, while the larger, sea salt nuclei appear to be of major importance in determining whether clouds produce rain. Attention is therefore concentrated on the study of the large hygroscopic nuclei.

These may be collected by exposing small prepared slides to the air through which an aircraft is flown. Fine spider webs also make suitable surfaces on which to catch the nuclei. The behaviour of the nuclei on the slide when exposed to moist air positively identifies them as being of sea salt. They are found in great numbers in maritime air and an effort is being made to discover how this number falls off as the air goes further and further inland. In this way it is hoped to explain why inland regions of the earth are, in general, more arid than those near the sea coast.

(*b*) *Freezing Nuclei.*—When water is cooled below 0° C. it normally does not freeze but becomes super-cooled. Thus water droplets in the super-cooled state are commonly found in clouds and are responsible for the serious hazard of aircraft icing. At temperatures below about — 15° C. the droplets will freeze spontaneously. However, there are materials which when brought into contact with super-cooled droplets will cause them to freeze at warmer temperatures. Once ice particles are present in a cloud of super-cooled droplets an unstable situation exists and rain follows. Silver iodide is an example of a substance that will cause freezing at the relatively warm temperature of — 4° C. There are other materials occurring naturally in the atmosphere which also cause freezing earlier than usual.

These freezing nuclei can be detected by bringing them into contact with a fog of super-cooled water droplets formed in a cold chamber resembling a deep freeze box. The water droplets turn to ice which has a very distinctive appearance when suitably illuminated. A cold chamber is being used on an aircraft to make a survey of the distribution of these freezing nuclei and to determine, if possible, their source.

(*c*) *Clouds.*—Once the cloud droplets have formed by condensation on nuclei the parameters that are of importance in a study of the rain process are the motion of the air which carries the drops upwards and enables them to grow, the air temperature which is responsible for the upward motion, the cloud droplet size distribution, and amount of liquid water present at the different levels throughout a cloud. Measurements are being made of all these quantities.

(i) *Air Movement and Velocity.*—The upward air velocity in a cloud is a major factor in determining its development, as also is the degree to which the environmental air is entrained into the updraught. Both these quantities are susceptible of measurement by a radar technique now in use. Bundles of light metal foil strips, which fall slowly and reflect radar signals, are dropped from an aircraft in the neighbourhood of the region in which the air movement is to be studied and their paths accurately followed by means of a ground radar equipment. The air movements both in clear air and around clouds are being studied by means of this technique.

(ii) *Cloud Temperature.*—Isolated cumulus clouds form in a rising current of air that is initially warmer than its environment. The growth of the cloud itself is a function of the temperature difference between the cloud and the surrounding air and the humidity structure of the environment. A study is being made of these temperature variations. For measurement of temperature inside the cloud special precautions are necessary to prevent the thermometer element becoming wet and the cloud droplets are centrifuged out from the centre of a vortex tube through which the airstream is made to pass.

(iii) *Cloud Droplet Spectra.*—The distribution droplet sizes in a cloud that does not contain ice appea to be of critical importance in determining wheth or not rain will fall from the cloud. A proportion larger than normal droplets is necessary, which gr by collision with the others. Measurements are ma from aircraft of the droplet spectrum in typical clou Magnesium oxide coated glass slides are exposed the droplets for a fraction of a second from an aircr flying through the cloud. The droplets impinge on t coating and leave holes proportional to their size. Tl technique has been applied successfully, in conjuncti with simultaneous observations of the distribution hygroscopic nuclei, to a study of clouds formed in ma time air. It appears that simultaneous observatio of this type will yield valuable information about t mechanism of cloud formation and growth.

(iv) *Cloud Water Content.*—Measurements are bei made of the liquid water content of convective clou The instrument used is mounted in an aircraft a gives a continuous record of the amount of liqu water present, which can be compared with th predicted from theory.

(*d*) *Rain.*—Study of nuclei and cloud droplets an essential preliminary to investigations of t physics of natural rain formation. Studies are ma of general rain processes, primarily with the aid radar both on the ground and in aircraft. Labo tory investigations are also made of the way in whi water droplets collide and coalesce.

(i) *Radar Studies of Rain.*—Radar has the uniq property of simultaneously enabling an examinati to be made of the precipitation elements througho any cloud within its range. It has been used exte sively to carry out a survey of different types of ra storms occurring naturally and to make detailed stud of particular storms. By a careful examination of t way in which the echo intensity varies from grou level to the top of a storm and a simultaneous obser tion of raindrop size distribution at the ground, kno ledge can be gained of the way in which the raindro grow in falling through cloud. To deduce the natu of the particles causing the radar echoes use is a made of the fact that the reflection from a no spherical ice particle differs from that from a raindr in having a marked cross-polarized component.

(ii) *Laboratory Investigations of Coalescence* Theoretical information has been available for so time of the way droplets in relative motion towa each other either collide or pass around each oth depending on their size and the air flow. This theo has been confirmed experimentally only in a ve limited range of droplet sizes, and one that is not particular importance in the rain process. By setti up a low velocity vertical wind tunnel and injecti into it a stream of small droplets of known size it proposed to study the coalescence process experime tally for a range of droplet sizes. In principle, t technique is to adjust the air velocity so that it j supports the droplets; any collisions result in the p duction of larger drops which then fall out. By inves gating the number of such falling drops relative those just supported in the airstream deductions a made about the collision process.

(*e*) *Artificial Rain Formation.*—Investigation continuing of methods of treating clouds to produ artificial rain. The dry ice process of rain-maki is now comparatively well understood and no furth work on this kind is being done at present.

An alternative method using silver iodide, which burnt to produce a smoke of fine particles, is kno to be capable of producing large numbers of crystals if injected into a super-cooled cloud at suitable temperature level. Spectacular claims ha

·n made in the United States of America about the ectiveness of this material when burnt in smoke gene- ors on the ground, reliance being placed on natural ivection to carry it up into the clouds. It is known, wever, that sunlight is capable of destroying the ectiveness of silver iodide under certain conditions d the material is very susceptible to chemical con- mination. The Division is investigating the way in iich silver iodide, released from a generator on the ound, diffuses down wind and whether it still main- ins its effectiveness at a distance. The technique is e same as that described earlier for the investigation natural freezing nuclei; that is, to catch the aterial in a sample of air and inject it into a box con- ining a fog of super-cooled droplets and observe those at turn to ice. The equipment is carried in an rcraft and the investigation made at different alti- des and distances from the smoke generators.

A further method of artificially producing rain is to ray small water droplets or place hygroscopic nuclei to the air at the base of a growing cloud. These par- eles are carried up by the air currents and grow by col- sion with the small cloud droplets in their path. hey fall out as rain when they have grown so large at the updraught can no longer support them. This ethod has been tried with water sprays and is now ıder investigation with hygroscopic materials. louds have been modified by the use of this technique, ıt not enough is yet known to judge of its economic ssibilities.

10. Wind Measurements at Great Heights.

(Division of Radiophysics.)

In August, 1951, a systematic series of observations wind velocity at altitudes from ground level to eights up to 100,000 feet was commenced. Observa- ons were made by using radar to track reflecting alloons released from the laboratory. Balloon ights were usually made five days a week and at mes additional flights were made every six hours ıd every half hour. A total of 320 flights were made efore the work was discontinued in September, 1952. he observations are now being analysed. It is xpected that the data will be of use in obtaining a etter knowledge of the conditions prevailing at alti- ıdes at which modern aircraft now operate and also give additional information about the general cir- ılation of the atmosphere.

11. Analysis of Rainfall Records.

(Section of Mathematical Statistics.)

(*a*) *Secular Changes in Rainfall in South Australia.* -Current work has confirmed the results of a previous nalysis at Adelaide and established the existence of nother long-term trend in the rainfall, the principal ıanifestation of which is the advancement of the spring ains by as much at three weeks. To date, this limatic change has been found 200 miles to the west nd to the north of Adelaide.

(*b*) *Correlation of Monthly Rainfall.*—The develop- ıent of climatology in Australia during recent years as made it increasingly important to interpolate for ıeteorological observations and, in particular, for ainfall. To investigate this problem, we must deter- ıine the extent to which different parts of the country xperience, in any given period, similar deviations from ieir average weather sequence, that is, we must deter- ıine the correlation of such weather deviations.

A knowledge of these correlations is essential to find ıe accuracy with which rainfall, or any other variate, ıay be estimated, at any given point, from known bservations at neighbouring points. The accuracy f such estimates must evidently depend upon the ensity with which observing stations are scattered in the region considered, and with a knowledge of the correlations it would be possible to state how densely located the stations should be to yield estimates with any assigned degree of accuracy. The same considerations apply when we wish to estimate the total precipitation in a catchment area to put on an experimental and quantitative basis such questions in meteorological physics as refer to localization of meteorological effects.

Two research projects were therefore undertaken on monthly rainfall. In the first (Annual Reports 1950-51, 1951-52), the correlation of rainfall of stations over an extensive area (400 miles north-south by 200 miles east-west) has been related to inter-station distance, and the axes of maximum and minimum correlation determined.

In the second project (Report 1950-51), an attempt was made to predict rainfall in terms of the position and altitude of the observing stations. On the whole, the technique led to accurate prediction, but under some circumstances, probably depending on local topography and aspect of the observing stations, there were large discrepancies. Predicted values are now being found from the product of factors depending on station and year.

(*c*) *Expectation of Monthly Rainfall.*—In preceding investigations on the expectation of monthly rainfall in South Australia the original data (monthly rainfall) were such as to allow general conclusions to be drawn from the results, but not the fine detail now being demanded in engineering, soil conservation, agriculture, and the pastoral industry. In the winter and summer rainfall zones, the climatic changes which take place with the advancement of the rainy season are too rapid for monthly data to provide an accurate description of the changes in progress, so that a finer subdivision of the year is required. The subdivisional unit chosen was six days, and a complete investigation has been made of the seasonal rainfall sequence at four observing stations—Adelaide, Darwin, Melbourne, and Forbes, New South Wales—which represent respectively, winter, summer, and two types of rainfall season in the transitional zone. This analysis gives a complete characterization of the season, since for any time of the year, the probability is known that a rainless spell of specified length will begin at that time, or alternatively, that a period of given length, in which the rainfall exceeds certain specified amounts, will also begin at that time.

The technique that has been developed is applicable to any type of rainfall season, and will have wide applications in a number of fields.

XXIX. EXTRATERRESTRIAL PHYSICS.

1. General.

Until recently our knowledge of the universe has been derived almost entirely from the use of visual telescopes and from the optical methods of observation developed by astronomers. A new branch of science, called " radio astronomy " has now developed in which radio instruments are utilized for the study of astronomical objects, and it is now possible to obtain much information about the Sun and the stars from the radio waves which they emit. In most cases these radio waves are generated spontaneously either as thermal radiation—which is analogous to the light given out from incandescent bodies—or as a consequence of electrical disturbances, in a manner similar to the production of atmospherics by lightning flashes. Radio waves are generated and propagated in a different manner from light waves, so that they provide new information which is often not obtainable in any other way. Radio astronomy has formed a major part of the research programme of the Division of Radiophysics (*see* Section 3 below). Work on solar radiation is carried out by the Division of Physics in Sydney (*see* Section 2 below). Studies of the ionosphere are carried out by the Radio Research Board (*see* Chapter XXVII., Section 7).

2. Solar Physics.

(Division of Physics.)

(*a*) *Emission of Radiation from Hot Atmospheres.*—Studies on the emission of radiation from hot hydrogen atmospheres have been published and results applied to the interpretation of physical conditions in solar prominences, as revealed by their Hα contours and brightnesses.

Recent computations at the Lyman Laboratory, Harvard, have given unexpectedly high values for the collision cross sections for transitions between the 2S and 2P substates of hydrogen. The effect of such large cross sections on the hydrogen emission is under investigation here, particularly to see whether there are crucial tests as to the magnitude of the 2S-2P cross section.

Calculations of the emission of hot atmospheres containing other elements, in particular helium and calcium, have been commenced. For the latter element, it has been necessary to calculate electron excitation cross sections.

Results of all these computations are required in the interpretation of observations of solar phenomena such as prominences, plages, flares, chromospheric granulation, and spicules.

(*b*) *Spectroheliograph Observations.*—The present spectroheliograph, consisting of a coelostat, horizontal telescope, birefringent filter, and cine camera, originally commenced operation with a 6 Å wavelength band centered on the Hα hydrogen line. As such, it was suitable for observations of prominences extending beyond the Sun's limb, but the large amount of sky light scattered by the city sky made such observations of limited value.

A narrow band (0.5 Å) filter has now been put into operation, and with it spectroheliograms have been obtained on 35-mm. film at $\frac{1}{2}$-min. intervals. The wavelength band is narrow enough to eliminate unwanted sky light so that prominences are clearly observed at the limb; but there is danger that fast moving prominences may not be recorded because of Doppler shifts. Furthermore, this filter introduces a considerable amount of scattered light, but by using an obscuring disk to produce an artificial eclipse of the Sun good photographs of prominences can be obtained.

Techniques have been developed for securing exposures in sequence on the chromosphere and on prominences at the limb, so that a complete composite picture may be obtained on cine-projection.

Some attention has been given to photographing the whole disk of the Sun at a lower magnification on 35-mm. film without loss of resolution, and considerable improvement has been effected by the use of special type film. The major factor limiting resolution is, however, always liable to be the large amount of atmospheric scintillation experienced in Sydney.

(*c*) *High Altitude Observations.*—Because of unsatisfactory atmospheric conditions in Sydney, consideration has been given to the advisability of establishing a field station in the Snowy Mountains area, where the clarity of the skies would be suitable for extensive solar observations.

To gain preliminary data on sky transparency and freedom from scattered light, photometers were constructed last year for measuring the sky brightness near the Sun, and these were used on several occasions for comparative tests on variation with altitude up to 3,000 feet on the Blue Mountains. In December, 1952, a small portable coronagraph was constructed and taken to Charlotte Pass, Mount Kosciusko, where at a height of 5,700 feet photographs were secured of coronal condensations using light of the coronal green line. Simultaneous sky brightness measurements showed the skies to be considerably purer than in the Blue Mountains area even in midwinter.

3. Radio Astronomy.

(Division of Radiophysics.)

During August, 1952, many of the world's best-known radio scientists were in Sydney for the Tenth General Assembly of the Union Radio Scientifique Internationale. This was the first occasion on which one of the International Scientific Unions had met outside Europe or the United States, and the choice of Sydney as the meeting place was a tribute to the achievements of Australian radio science.

To radio astronomers the Conference had a further significance in providing one of the early milestones in the path of the new science of radio astronomy. Radio astronomy, the study of the Sun and Galaxy by means of radio waves, has reached the end of its first exploratory stage in which existing tools were employed, and is about to start on a new stage for which new tools will be needed. One of these new tools will be the huge radio telescope now being constructed near Manchester in England. This will be used to study the detailed structure of the radio emission from the Galaxy.

Although Australia had as yet no plans for comparable equipment to show the overseas visitors, several new and specialized types of equipment were seen in operation, which are in advance of any in use elsewhere. One of these is a radio-spectrometer which analyses the radio emission from the Sun into its various components in the range of wavelengths from 1.4 to 8 m. Another new piece of equipment in use is a 32-aerial interferometer, which is probably the most highly directional aerial system ever constructed. This aerial is used for studying details of the emitting surface of the Sun. A third new type of equipment, constructed shortly after the Conference, is an experimental model of a radically new type of directional aerial system which will be used, at a wavelength of 4 m., for a detailed study of the Galaxy.

The development of new tools is not the only sign, however, of the beginning of a new stage in the progress of radio astronomy. There appeared at the Assembly the first results of close collaboration between Australian and English radio astronomers and optical astronomers working with the largest telescope in the world at Mount Palomar.

(*a*) *Radio Waves from Outside the Solar System.*—(i) *Discrete Sources.*—In 1947, members of the Radiophysics Laboratory discovered and located the position of a discrete source of radio emission in the direction of the constellation of Cygnus. Since that time many more such discrete sources have been discovered, both here and in England. These sources are popularly known as radio stars. In most cases the identification of the radio sources with visible celestial objects has not been found possible, and the nature of the discrete radio sources has remained a mystery. Recently, the 200-in. telescope at Mount Palomar has been used to scan the position of the radio source in Cygnus and the discovery has been made that in this position are two galaxies or "island universes" in collision. These galaxies are so far away that it has required the use of the largest telescope in the world to resolve them; yet they form one of the strongest sources of radio emission. Unlike our own Galaxy, they radiate roughly as much radio energy as light energy. If similar conditions occurred in our Galaxy, most radio communication would become impossible because of intense interference from cosmic radio noise.

fact that this source is so intense at radio fre-
es, yet optically is near the lower limit of observa-
cause of its great distance, suggests that some of
aker sources may be so far away that they are
l the reach of our largest telescopes. Radio
omy may already be giving information about
usly unknown parts of the universe.

ing the past year the sizes and approximate
s of several of the stronger sources have been
ained and found to conform, usually, with the
s and approximate sizes of certain visible nebulae.
ar work with different techniques was conducted
taneously in England and similar conclusions were
ed.

) *Line Emission from Galactic Hydrogen.*—The
ery at Harvard in 1951 of an emission line from
c hydrogen in interstellar space was an event of
reatest importance in astronomy. As well as
ng the existence of hydrogen in interstellar space,
iscovery provided the first "line-emission" type of
tion for use by radio astronomers. This type of
ion can give very much more information about its
e than can the "continuous" type of radiation; by
eans it may be possible to delineate the structure of
alaxy. Early work here showed the general shape
e source of radiation and also gave evidence that
alaxy has a spiral structure. More accurate and
rate equipment has now been designed and con-
ted to continue this study. First results have
nstrated the presence of hydrogen in both the
ds of Magellan. The possible existence of
dges" connecting the two Clouds and our own
xy is now being investigated. This will help to
w light on the origin and structure of the Galaxy.

) *Radio Waves from the Sun.*—Since life on Earth
mpletely dependent on the Sun, the interest of
nomers in the structure of the Sun and in the
ges that occur on it is understandable. The changes
e emission from the Sun, fortunately, are small,
rwise life on the Earth would be destroyed. The
l changes that do occur, however, may cause a
tion in long-distance radio communication on the
th and may produce aurorae and other disturbances
he Earth's upper atmosphere. A large 32-element
ferometer has been constructed to produce an
al-beam so narrow that the emitting surface of the
may be studied in detail. Particular attention has
paid to localized "bright" areas on the solar disk,
earing near sunspots. It is in these areas that
urbances arise, producing effects on the Earth. A
y has been made also of the "background" solar
ation, which is the radiation from the Sun in the
nce of localized bright regions. This investigation
roducing information on the physical conditions in
Sun's atmosphere.

he new radio-spectroscope has been employed in
lysing "bursts" of radio emission from the Sun. A
phenomenon, the production of "harmonics" of
sts, has been discovered. This gives a most signifi-
t clue to the mechanism of production of bursts and
vides also a new means of measuring the velocity of
ticles which are shot off from the Sun during a
io burst and, in part, eventually reach the earth
sing radio fade-outs, magnetic storms, and aurorae.

outine observations of solar radiation, on seven
erent wavelengths, are continuing. The results, with
se obtained in the rest of the world, are edited here
publication in the *Bulletin of the International*
ronomical Union.

XXX. ATOMIC PHYSICS.

1. GENERAL.

The Organization has co-operated with the University of Melbourne in a programme of research on nuclear physics and cosmic rays, under the direction of Professor L. H. Martin. Both activities have a common aim, namely, the study of the forces within the nucleus of the atom, but while the former uses high-speed particles artificially produced in the laboratory, the latter analyses the disintegration produced in the upper atmosphere by high-speed particles reaching the Earth from outer space. Work on these projects is described in Sections 2 and 3 (*a*) of this Chapter.

Co-operative investigations on cosmic rays are also being undertaken at the University of Tasmania under the direction of Professor A. L. McAulay, and are reported in Section 3 (*b*) of this Chapter.

In collaboration with the Commonwealth Department of Health, arrangements have continued for procuring supplies of radioactive isotopes from overseas and for their handling and distribution to research workers in Australia. This work on tracer elements investigations is described in Section 4 of this Chapter.

2. NUCLEAR PHYSICS.

(University of Melbourne.)

(*a*) *Equipment.*—Much of the work of the Section during the past year has been concerned with angular correlations between particles participating in nuclear reactions, with nuclear energy level determinations, and with scattering investigations. Two major items of equipment have been added to the laboratory resources during the past year. A 200 kV. electronic multiplier machine has been completed. It is intended that this machine will primarily fulfil the role of a neutron generator. Also the new ten-channel pulse height analyser has been used successfully in several investigations. Apart from these additions to laboratory equipment, some further minor changes have been made in existing installations to improve performance, notably with the 1 MeV positive particle accelerator, and the redesign of the electron synchrotron is proceeding. Formerly the upper energy limit of this machine was 14 MeV.; it is believed that the rebuilt machine will give electrons of 25 MeV. energy.

(*b*) *Nuclear Reactions and Energy Level Experiments.*—Investigations are continuing with the 1 MeV. electrostatic generator. Nuclear data suggest that seven charged particle reactions are energetically possible when deuterons and protons are incident on ^{17}O and ^{18}O targets. These possible reactions, only one of which has been reported as observed [^{18}O (p,α)], are being investigated using the nuclear plate technique. Evidence has accumulated suggesting the existence of several expected particle groups, but the picture is somewhat confused owing to the effects of ^{12}C, ^{13}C, and ^{15}N contaminations. Present efforts are concentrated on reduction of these persistent contaminations.

Another investigation with this machine has been concerned with neutrons emitted in the deuteron bombardment of beryllium and carbon. Examination of the neutron spectra resulting from the reaction ^{9}Be (d, n) ^{10}B by the nuclear plate technique has given a Q value for this reaction of 4.35 MeV. in agreement with the value 4.36 MeV. given by the nuclear masses. Four energy levels of ^{10}B were confirmed with energies 0.73, 1.75, 2.20, and 3.64 MeV. Two other neutron groups were observed, one of which could be attributed to D-D neutrons. The other group was in disagreement with neutron energies obtained from possible target contaminants and could best be explained by an energy level in ^{10}B at 2.85 MeV. Further measurements relating to the ^{13}C (d, n) ^{14}N reaction have been made in order to ascertain the origin of this group. This will also give information on the energy levels of the ^{14}N nucleus.

(*c*) *Angular Correlation Experiments.*—In order to provide information on the low excited state of ^{7}Li the angular correlation between the α- particles and γ-radiation from the reaction $^{9}\mathrm{Be}(d,\alpha)^{7}\mathrm{Li}^{*}(\gamma)^{7}\mathrm{Li}$ has been measured with the 750 keV. electrostatic generator. The results show no significant departure from isotropy. The most plausible explanation is that the lowest excited state of ^{7}Li has spin $\frac{1}{2}$, but isotropy could also arise through fortuitous channel spin degeneracy or through an anomalous magnetic dipole-electric quadrupole γ-radiation admixture. The angular distribution of the γ-radiation is now being investigated, because for this excited state the channel spin degeneracy leading to an isotropic correlation cannot also lead to an isotropic distribution.

Investigation of the relevant theory shows that the condition for isotropy of the correlation due to the dipole-quadrupole admixture depends only on the admixture, thus being independent of the reaction leading to the excited state of ^{7}Li.

By means of the electron synchrotron a study has been made of the spatial distribution of the photoprotons from deuterium produced by the synchrotron X-ray beam in a Wilson cloud chamber. It showed that the protons are not emitted with equal probability at all azimuthal angles, as is expected from theory. In order to obtain better statistics, this problem is being pursued using nuclear emulsions soaked in heavy water. The immediate aim of the work has been to examine the γ-radiation from the 14 MeV. synchrotron with respect to possible polarization of the radiation. Results have been inconsistent to date. Early results suggested appreciable anisotropy in the spatial orientation of the photoprotons and it has not been decided whether this is real or of instrumental origin. An independent approach is planned, using proportional counters operating on deuterium gas. From this study is also being obtained the spectral distribution of the target radiation. Further work with the cloud chamber has been suspended owing to the relative paucity of X-ray output from the synchrotron under pulsed operation.

Using a reaction camera which was designed and built during the year, the photoprotons emitted in the photodisintegration of nitrogen are being studied. The proton energy distribution indicates that the $^{14}\mathrm{N}(\gamma,p)^{13}\mathrm{C}$ cross section must rise to a maximum at about 10 MeV. and then fall to almost zero at about $12\frac{1}{2}$ MeV. The observed angular distribution is consistent with a curve of the form $A + B \sin^{2}\theta \cos^{2}\theta$, which indicates that in nature the disintegration process is a mixture of magnetic dipole and electric quadrupole transitions.

(*d*) *Scattering Experiments.*—Work with the magnetic lens β-ray spectrometer on the investigation of scattering of electrons and positrons by gold has now been completed. The results obtained accord well with theory, and confirm the magnitude of the ratio of the intensities of the scattered electrons and positrons and the variations of this ratio with scattering angle.

Another scattering investigation in progress using the 1 MeV. electrostatic generator concerns the multiple scattering of protons in nuclear emulsions. Protons from the deuteron bombardment of ^{6}Li, ^{12}C, and ^{24}Mg recorded on Ilford C2 emulsions have been used to give tracks of known range corresponding to various energies between 0 and 5 MeV. The lateral displacement of the end of each track from its initial
direction is measured as projected on the plane of t
emulsion. The standard deviation of the observed d
tribution can be compared with the theoretical calcu
tions. Preliminary results indicate that the Willia
theory is in reasonable agreement with experime
whereas the Molière theory tends to give results wh
are too high. Further work is being done to confi
these results.

3. Cosmic Rays.

(*a*) *University of Melbourne.*—The cosmic ray sp
trometer determination of the variation of the speci
ionization of cosmic ray mesons as a function of th
momentum has been completed and the results pu
lished. The final results, comprising measurements
6,400 meson tracks, showed an increase of speci
ionization with increasing momentum of the prima
particle in good agreement with that predicted
theory. The measurements are of additional interest
the region above 10^{10} eV/c., since they show qu
plainly the flattening off of this rise of ionization d
to the polarization of the medium.

In the course of this experiment it was found th
the distribution of energy losses for mono-energe
particles traversing an absorber in which the ener
loss is very small compared with the total energy of t
particle is appreciably broader than that predicted
existing theories. An investigation of this discrepan
is being made at the present time.

The measurements of the meson momentum distri
tion and +/— ratio at zenith angles of 30 and 6
are now complete. Preliminary analysis shows th
the shift to higher momenta of the peak of the dist
bution, expected from the longer atmospheric path,
verified.

A considerable area of the nuclear emulsion pla
exposed in the Himalayas during 1951 has be
scanned. Data have been accumulated for heights
to approximately 18,000 feet on the slow and fast co
ponents of the neutron flux in cosmic radiation, a
on star production as a function of altitude. Th
data are now being correlated along three lines: (
to check the existing data on altitude variation of t
neutron flux; (*b*) to correlate the neutron flux wi
star production in the atmosphere; (*c*) to derive
value for the rate of production of radio-carbon (^{14}
in the atmosphere.

More recently this work has been extended
greater heights in conjunction with the balloon tea
of the Melbourne University Physics Department, a
to different latitudes in conjunction with resear
institutions in other parts of the world.

(*b*) *University of Tasmania.*—Directional measu
ments of the cosmic ray intensity at Hobart have be
continued. Data from these measurements as w
as data from previous years are being examined
relation to the variation of cosmic ray intensity as
ciated with meteorological fronts, and the diurn
variation of the east-west asymmetry.

4. Radioactive Tracers.

(Tracer Elements Investigations.)

This Unit has continued to assist other laborator
and establishments in problems associated with the u
of isotopes in non-medical research. Work has co
tinued on the synthesis of isotopically-labelled co
pounds, and independent research has continued usi
^{14}C in organic molecules. In July, a member of t
staff commenced a year's study-leave in the Unit
Kingdom, at the Radiochemical Centre, at Amersha
and the National Institute for Medical Research, M
Hill, where he is obtaining experience in the techniqu
applied in these establishments. In October, Dr. T.

)d e was awarded a Fulbright Travel Grant and f for the United States of America, having been ted two years' leave of absence for work with oisotopes in the University of Arkansas.

) *Procurement and Distribution of Isotopes.*— volume of requests for labelled compounds handled y this Unit for other Divisions and Sections has o inued to grow, and increased supplies of isotopes lable from England have allowed greater endence on this source with the consequence that erican supplies are now rarely used.

sotopes obtained have covered a wide range and ude both organic and inorganic molecules for kers in many diverse fields of research and development.

b) *Advisory Work.*—Inquiries from various sources arding techniques applicable to work with radioive compounds have been received and some assisce rendered regarding equipment useful in this field. o workers from universities have visited the Unit, dying such practices of synthesis, assay, and asurement as are used in this laboratory. Several earch organizations converting or erecting laboraies expressly for the purpose of isolating work with lioactive compounds have been advised on design and uipment.

Preliminary tests were made in collaboration with e Department of Supply on the possibility of the tection of buried shells by radioactive marker ethods. It has been found practicable to locate urces of moderate activity in up to eighteen inches soil, using portable Geiger counters. Further assisnce has also been afforded the Irrigation Research ation at Griffith in studies of the diffusion of ^{22}Na rough soils, and some work on the use of isotopes in e elucidation of part of the life cycle of certain cattle ks has been initiated in conjunction with the ivision of Entomology, Rockhampton.

(*c*) *Equipment.*—Apparatus for the development of ore precise counting methods is being assembled, with e intention of assaying gas samples by proportional unting techniques, thus facilitating work with lower tivities than is possible with more conventional techques of assay, particularly with ^{14}C-labelled comunds.

The properties and characteristics of certain halogenenched liquid counter tubes have been studied intenvely in conjunction with the Central Experimental orkshop in an attempt to find the optimum conditions r the operation of these tubes. This work is connuing.

(*d*) *Synthesis and Applications of Labelled Comunds to Certain Studies.*—The synthesis of certain C-labelled and ^{35}S-labelled acids not available overas have been performed. Routes for preparation of range of aryl- and alkyl-substituted α-glycols ^{4}C-labelled) have been explored and synthetic work gun, while certain ketones, aldehydes, α-diketones, d acyloins are being prepared. These compounds are quired for studies of reaction mechanisms and isotope ects, which are being pursued. Certain plant rmones are also in stages of preparation, labelled th ^{14}C or ^{35}Cl.

Radioactive sources of various types have been ranged for workers as required.

XXXI. MATHEMATICS.

1. General.

Mathematical work plays an important part in all ases of the Organization's research programmes. A parate Section of Mathematical Statistics has been aintained to provide workers in the various Divisions d Sections with special help in planning their searches and analysing their experimental results.

Work on mathematical instruments and mechanical and electrical methods of computation is undertaken in the Section of Mathematical Instruments. Work on computing equipment is also undertaken in the Division of Electrotechnology (*see* Section 4 of this Chapter) and in the Division of Radiophysics (*see* Section 3 of this Chapter).

Section of Mathematical Statistics.—The main function of this Section is to provide mathematical assistance to officers of the Organization in the planning of experiments and the interpretation of results. Much of the Section's work is described in other chapters, and a number of officers of the Section are attached to certain Divisions of the Organization or at appropriate centres—Canberra, Melbourne, Sydney, and Perth.

A large number of requests for assistance are received from outside bodies such as universities, State and Commonwealth Departments and commercial enterprises. In addition a good deal of time has been spent on lecturing both to junior staff and to university classes.

The Section has greatly benefited from the visit of Sir Ronald Fisher, F.R.S., who came to Australia in March at the invitation of the Organization and spent his seven weeks' sojourn in the laboratories of the Organization discussing mathematical statistics and its applications with Sectional staff and other interested officers.

The Section has also vigorously pursued its own research programmes. Work on analysis of rainfall records is described in Chapter XXVIII., Section 11, and that on statistical studies of sheep breeding, done in collaboration with the Division of Animal Health and Production, is recorded in Chapter VII., Section 13 (*d*). Apart from this and other work described elsewhere, research projects undertaken by the Section are described in Section 2 of this Chapter.

Section of Mathematical Instruments.—This Section is located in the Electrical Engineering Department of the University of Sydney, under the direction of Professor D. M. Myers. It is concerned with the investigation of analogue and digital computing devices, and with the operation of the differential analyser. This work is recorded in Section 5 of this Chapter.

2. Analysis.

(Section of Mathematical Statistics.)

(*a*) *Transformations of Discrete Variates.*—Functional transformations of a random variable are used to render the variances of experimental data homogeneous, that is, independent of their means. In particular, data in the form of frequencies generally require transformation before analysis. For many discrete distributions, one or more values of the population mean lead to a degenerate distribution concentrated at one value and, consequently, there is, in general, no functional transformation which will result in constant variance. To meet this difficulty, a different type of transformation has been developed in which one or more of the original values are replaced by a random variate, rather than by a single new value. For many distributions of unlimited range, only one original value need be thus transformed, the other values undergoing a single-valued transformation.

General recurrence relationships, for determining the transformed values successively, are derived. For the Poisson distribution, the transformed values are given explicitly, the larger values being obtained from an asymptotic formula.

(*b*) *Tests of Significance for Concurrent Regression Lines.*—The fitting of a straight regression line to a set of observations on two variates is a straightforward application of the method of least squares. Where there are several sets of such data, it is of interest to fit regression lines for each set, and to determine whether or not the slopes of the lines differ more than would be expected from chance variations. Where the slopes of a set of lines do not differ significantly the interpretation of the data is particularly straightforward, since the comparison of the sets may be made simply by comparing the constants of the regression equations. In fact, if these constants also do not differ significantly when a single slope is used for all lines, then the regression may be regarded as completely homogeneous and a single equation used to represent the relationship for all the data.

The case of parallel regression lines is particularly important in many applications; for example, the comparison of two materials by means of biological assay can be carried out satisfactorily only when the regression of response (suitably measured) on dosage is linear and has the same slope for each material. The relative potency is then measured as the distance between the parallel lines, measured in a direction parallel to the dosage axis. When the regression lines are not parallel, the interpretation is difficult or impossible.

Another case which appears to be important but has not received so much attention is that in which the regression lines, instead of being parallel, are concurrent. This type of effect is likely to occur when different materials produce a different rate of response, while all give the same response at some fixed level. This level in practice is often not zero, and often not exactly known. When three or more regression lines are concurrent, it is possible to measure the difference between the effects of different materials or treatments by means of the ratios of the distances between the lines measured along an ordinate. It will be seen that parallel regression lines are simply a special case of concurrent lines; in fact, the ratio of the effectiveness of different materials may be measured in precisely the same way as for concurrent lines, that is, by the distances between the intercepts on a transversal.

(*c*) *A Method of Analysis for Double Classifications.*—Surveys or experiments which are designed to throw light on the effects of two or more factors on some characteristic often provide data which are classified by the classes of each factor in two or more different ways. For the assessment of the effects of each factor, it is necessary to derive estimates of these effects, freed from any possible influence of the effects of other factors. Provided that the number of results in each subclass of the multiple classification is the same or proportional, the analysis and interpretation of the data are straightforward, and the methods to be used are well known. When the subclass numbers do not satisfy these requirements, the methods of analysis, both to arrive at unbiased estimates of the effects of each factor and to determine valid estimates of the experimental error, are more complicated. Various exact methods for treating data of this type are known, but for some purposes approximate methods are sufficiently accurate. Such a method, which has proved useful for double classifications, has now been devised. It is valid when the factors are independent so that their effects are additive, a condition that is often approximately satisfied in practice.

(*d*) *Analysis of Rainfall Records.*—The research projects in this field of investigation have continued and are reported in Chapter XXVIII., Section 11.

(*e*) *Statistical Studies on Sheep Breeding.*—These collaborative investigations between the Section of Mathematical Statistics and the Division of Animal Health have continued and are described in Chapter VII., Section 13 (*d*).

3. HIGH-SPEED COMPUTATION.

(Division of Radiophysics.)

Effort has been concentrated upon the final develo
ment and use of the electronic computer. On the eng
neering side the high-speed store has been extend
in capacity and is approaching the limit of 1,0
numbers. The use of punched cards has been disc
tinued, punched paper tape being now the mediu
for providing data to the machine. This allows mo
rapid and reliable insertion of information. Develo
ment of editing and rapid recording equipment is p
ceeding. Punched cards will be used only as an au
liary to the tape used in the machine and the editi
equipment will include devices for automatic trans
of data between cards and tape. In the field of p
gramme design, there has been considerable extensi
of the library of standard routines, which now inclu
routines for performing the more complicat
functions, such as the arithmetic of complex numb
in floating index form and of multiple length numbe
The use of these routines greatly reduces the amount
work needed to programme the more complicated ty
of calculation. The machine has been used in
solution of linear equations, partial differential eq
tions, the evaluation of determinants, compilation
tables, and statistical analysis of experimental data.

Other work has included the evaluation of tables
use in radio astronomy and in optics. In the latter c
an extensive six-decimal table of the Fresnel integ
has been compiled and is being used in a study m
tioned below.

Evaluation of the hydrodynamical flow at l
Reynolds numbers around spheres has proceeded a
the final stages of the calculations are being complet
using punched card methods and the relay multipl
which has recently been completed and placed into s
vice. This device is an all-relay type of decimal mul
plier, and is coupled to a standard "Hollerith"-ty
reproducing punch. These calculations are expected
show at what range of Reynolds numbers the transiti
from viscous to streamline flow takes place.

A study of the nature of an optical focus in
presence of aberrations has continued and has requi
the solutions of partial differential equations, wh
were evaluated by use of the differential analyser in
Section of Mathematical Instruments.

4. ELECTRONIC COMPUTATION.

(Division of Electrotechnology.)

A group of four of the direct-reading scale-of-
counter tubes previously developed has been dem
strated in England and Europe. Further technical
formation and sample tubes have been supplied
manufacturers in England and the United States
America interested in producing these counter tub
Mathematical work on the effect of space charge
disturbing the focus of circular electron beams
resulted in the derivation of a simplified formula
the calculation of this effect.

In collaboration with the Electrical Engineeri
Department of Sydney University, a new method
solving potential distribution and other proble
similar in form has been originated.

The electron trajectory computer built previously
being redesigned to extend the range of problems
which it is applicable. When complete it is propos
to make the services of this equipment available
electron-tube and other manufacturers.

5. COMPUTING INSTRUMENTS.

(Mathematical Instruments Section.)

(*a*) *Differential Analyser.* — The different
analyser has operated continuously throughout
year, apart from a short period set aside for additio

d maintenance. A number of problems has been
lved for the Organization and for outside bodies.
hese include several successful investigations of par-
l differential equations and some lengthy problems
nnected with the electron density in the ionsphere
d with the response of an aircraft to graded gusts.
nproved speed control and safety circuits have been
corporated in the machine, together with further re-
ansmission units and plotting tables. Other new units
mmenced include an extended control cabinet, genera-
r power supply, eight simplified integrators, and a
leprinter output. In conjunction with the staff of
e New South Wales University of Technology, in-
stigations have been carried out on continuous M-
pe transmission, and the operating principle estab-
hed of an improved type of curve follower.

(*b*) *Digital Machines.*—Work has continued in the
velopment and application of beam deflection valves
r digital computing and is now almost complete. A
lve has been developed and tested which is capable of
nary addition, subtraction, or control of a gate by a
stable, monostable, or counting element. The per-
rmance is comparable with that achieved in conven-
onal circuits, but the saving in valves and components
considerable. The work has established desirable pro-
rties for a universal computing element. Publication
awaiting a provisional patent. Essential develop-
ent work on a cathode-ray tube storage system has
en completed and tests made of alternative methods
charge storage. Reliability tests have been run with
st patterns over a period of several months. These
ave provided useful data on components and operating
ethods. The average time between faults has been
nproved to fifteen hours, the main source of trouble
w being valve failures.

XXII. PUBLICATIONS AND INFORMATION.

1. GENERAL.

The Organization's research results are made avail-
ble through various channels.

Formal scientific publication is supplemented in
everal ways: by the preparation of films (Section 4
this Chapter) which may, for example, give a
rmer or extension officer more help in diagnosis of
nimal diseases than would a list of clinical data; by
e continuous and close contact with industry of
fficers of the Divisions and Sections, through whom
uch information—derived from the literature,
ccumulated knowledge and experience, and current
esearch—is disseminated; by the provision of facili-
es for guest workers in laboratories; by the publica-
on of trade circulars, newsletters, and articles for
ade journals; by press releases; by lectures and short
ourses of specialized training; and by the organization
specialist conferences.

The application of research in the primary indus-
ies is being assisted by the work of the Agricultural
esearch Liaison Section established in 1951
Section 3).

Other sections of this Chapter describe the work
the Organization's Libraries (Section 5); the
ranslation Section (Section 6); the Information and
ocumentation Sections (Section 7); and the Overseas
iaison Offices (Section 8).

2. PUBLICATIONS.

In collaboration with the Australian National
esearch Council the Organization has in the past
ublished the *Australian Journal of Scientific
esearch,* Series A dealing with the physical sciences
nd Series B dealing with the biological sciences.
hese two journals have now been replaced by three
ew publications: the *Australian Journal of Physics* (published in collaboration with the Australian National Research Council and the Institute of Physics); the *Australian Journal of Chemistry* (published in collaboration with the Australian National Research Council and the Royal Australian Chemical Institute); and the *Australian Journal of Biological Sciences* (published in collaboration with the Australian National Research Council). In addition, two new periodicals have been started, also published in collaboration with the Australian National Research Council, under the titles of: *Australian Journal of Botany,* and *Australian Journal of Zoology,* to cater for the more descriptive phases of the biological sciences.

The various scientific periodicals published by the Organization are, therefore—

Australian Journal of Agricultural Research—Issued quarterly.
Australian Journal of Applied Science—Issued quarterly.
Australian Journal of Biological Sciences—Issued quarterly.
Australian Journal of Botany—Not issued at regular intervals.
Australian Journal of Chemistry—Issued quarterly.
Australian Journal of Marine and Freshwater Research—Not issued at regular intervals.
Australian Journal of Physics—Issued quarterly.
Australian Journal of Zoology—Not issued at regular intervals.

The Organization's research results are published in the above journals, in its Bulletins and other special series of publications, and in papers contributed to specialized scientific journals both in Australia and overseas. The above journals are also open to workers not attached to the Organization for the publication of papers of substantial merit.

A complete list of scientific papers published during the year by officers of the Organization will be found in Chapter XXXV.

Other publications issued by the Organization during the year include—

(1) Volume I. of a monograph: "The Grasshoppers and Locusts (Acridoidea) of Australia", by Dr. James A. G. Rehn, dealing with the families Tetrigidae and Eumastacidae. Dr. Rehn is Curator of Insects at the Academy of Natural Sciences of Philadelphia and was asked to undertake this compilation.

(2) "Australian Termites", by F. W. Ratcliffe, F. J. Gay, and T. Greaves. This book has been prepared to provide the non-specialist reader with accurate information on the biology, recognition, and economic importance of the common species of Australian termites.

(3) "A Manual of Australian Soils", by C. G. Stephens. This provides a brief account of the system of soil classification in use in Australia before 1925, an outline of the modern system of classifying soils on the basis of their morphology, and a classification of Australian soils, with colour photographs and morphological descriptions of the profiles.

(4) A new series of "Soil Publications" reporting research in the field of soil science, including soil surveys and related investigations of interest to specialists in this field. No. 1 of the series entitled "Pedology of Deniboota Irrigation District, N.S.W." has now been issued. Earlier work of this sort was reported in the Bulletin series.

(5) A new series of publications, " Land Research Series ". These report the work of the Land Research and Regional Survey Section in the systematic surveys of natural resources it is undertaking in undeveloped areas in northern Australia. Two publications have now been issued in the series: " Survey of the Katherine-Darwin Region, 1946 " and " Survey of the Townsville-Bowen Region, 1950 ".

(6) The first draft of a " Directory of Australian Scientific and Technical Research Centres " containing information on groups in Australia currently engaged in research in pure science, technology, agriculture, veterinary science, and medicine.

3. Liaison Between Agricultural Research and Extension Work.

The Agricultural Research Liaison Section was formed to ensure that the Organization's research results are made available to State Departments of Agriculture for use in their extension work with farmers. Increased interest in agricultural extension work has followed the Commonwealth extension grant to State Departments for the general purpose of increasing agricultural production.

The work of the Section is concerned mainly with marshalling important research material and presenting it in suitable form through publications and at conferences with State extension authorities.

During the year there were three issues of the liaison periodical *Rural Research in C.S.I.R.O.*, and it has now been established as a quarterly. Two more of the series of publications describing research financed from wool funds have been produced: " Towards More Wool " and " Better Pastures for the N.S.W. Tablelands ".

Conferences between research and extension officers are held to deal with recent research results requiring more detailed explanation and discussion. The Section, in conjunction with the New South Wales Water Conservation and Irrigation Commission, assisted the New South Wales Department of Agriculture in the organization of an irrigation conference held in October and November, 1952, at Yanco, New South Wales. It aimed to provide an interchange of knowledge and ideas between research and extension workers, engineers, and administrators associated with various aspects of irrigation, and in particular the irrigation of orchards and row crops. The 60 delegates from all mainland States recommended that a similar course dealing with the application of water to pastures should be held during the 1953-54 season at centres in Victoria and the Riverina.

The Section co-operated with the New South Wales Department of Agriculture in a conference-tour of the Southern Tablelands region, organized by the Department and concerned primarily with the practical application of recent research in establishing improved pastures in this area. This on-the-spot co-operation between research officers of the Organization and extension officers of Departments of Agriculture is expected to be the forerunner of a series of similar conference-tours in specific regions.

There is often considerable scope for improved means of presenting more difficult research findings at conferences or courses. In connexion with the Yanco irrigation course the Section devised an analogue method of presenting the principles of applying water to soils, using earth models and selected small flows. The method is being extended to border irrigation and shows promise as an auxiliary to field research.

The Section works with the Film Unit in the production of films on rural topics, and in art work associated with the Unit's general activities. Three irrigation films are being produced in co-operation with the New South Wales Department of Agriculture. The first—" Salting and Reclamation "—was issued in December, and has had a wide distribution. The two other films—" Irrigation and Farm Design " and " Supply and Drainage Ditches "—are nearing completion.

Inquiries involving direct extension advice are referred to State extension authorities for reply; about three-quarters of the 500 inquiries received during the year were referred to State Departments and others.

4. Film Unit.

During the year the following films were completed and released:—

" Soils and Foundations "—16 mm., colour, sound, screening time 21 minutes, released July, 1952. Made at the request of the Division of Soils, this film deals with problems arising from the building of brick and masonry houses on certain troublesome types of clay soil. The importance of recognizing the soil type on each building block is stressed, since this is the key to the physical properties of the soil and so to the appropriate foundation design.

" Salting and Soil Reclamation "—16 mm., colour, sound, screening time 22 minutes, released August, 1952. This film was made in collaboration with the Murrumbidgee Irrigation Areas Agricultural Service of the New South Wales Department of Agriculture and is intended primarily for farmer extension purposes. It describes how salt gets into the soil in the first place; how, in arid areas, there is a delicate balance between the salt distribution in the soil and rainfall and vegetation; how this balance can easily be upset by irrigation and particularly over-irrigation; how salting kills trees and crops; how salting often can be prevented by careful and correct irrigation practice; how land already salted can often be converted to pasture; and finally the various tile drainage methods which are the only sure preventives of salting and its only effective cure.

" The Argentine Ant "—16 mm., colour, sound screening time ten minutes, special release March, 1953. Made for the Division of Entomology in collaboration with the New South Wales Department of Agriculture and local health authorities, a special copy of this film was released for use by the New South Wales Department of Agriculture at the Sydney Royal Easter Show. It is now being modified so as to be more suitable for use by local health authorities in instructing spray gangs in the proper method of using chlordane spray in campaigns aimed at the eradication of the ant. When so modified the film will be available for general release.

A short, 16-mm., silent, colour film entitled " Queensland and New Guinea Fibre Experiments " was assembled and edited for the Officer-in-charge, Plant Fibre Section, who himself made the cine records on an official visit to those areas in 1952.

Films on the following subjects are in the course of production:—

" The Mutton Birds of Bass Strait "—awaiting seasonal mass migration shots.

" Design for Irrigation "—due for release in October, 1953.

"Supply and Drainage Ditches"—to be completed by June, 1954.
"Bovine Contagious Pleuropneumonia"—due for release December, 1953.
"Chain Saw Sharpening Techniques"—due for release October, 1953.

he demand for the Organization's films has con- ued, and prints of most recent productions are held the Australian National Film Library and an appro- ate State authority in each State, also by the Aus- lian Scientific Liaison Offices in London and ashington. Prints have been purchased by N.E.S.C.O., F.A.O., and certain British Common- alth countries. During the year some 280 film okings were made of prints held in the film library. reenings have been arranged on research subjects to terested groups of officers from the Organization, ate Departments, Universities, and industry. An rlier production "Radiophysics 1949" was selected d exhibited at the 6th International Edinburgh Film estival held 17th August to 7th September, 1952. A rtificate to this effect has now been received from e Festival.

5. LIBRARIES.

It was found possible during the past year to carry ut a comprehensive revision of both the text-book and eriodical collection at the Central Library. Libraries the various Divisions and Sections of the Organiza- ion have continued to function and expand their ervices. Co-operative reference work in Australian ibraries is gaining momentum and increasing numbers f inquiries are being received for scientific and tech- ical publications from libraries in all States.

A Supplement to the second edition of the *Union atalogue of Scientific and Technical Periodicals* is in ress and will be available shortly. The Supplement ontains only titles of periodicals which have com- enced publication since January, 1946. Work ill commence shortly on a more comprehensive upplement covering alterations which have taken place library holdings since the publication of the second dition.

Administrative changes during the past year brought hat was previously known as the Documentation Sec- ion of the Information Service under control of the ibrary. This Section has been responsible for a publi- ation under the title of *Abstracts of Published Papers nd List of Translations* which is being issued in uplicated form in limited numbers and distributed to ibraries both in Australia and overseas. The Abstracts over papers published by the research staff of the rganization in its own publications and in other cientific journals.

A small duplicated edition of a first draft of a *irectory of Australian Scientific and Technical esearch Centres* has also been issued. Making use f the experience that has been gained in the compila- ion, it is hoped later to publish a revised edition in rinted form.

6. TRANSLATION.

The Section has performed translation, written and ral, for the Organization's Divisions and Sections. ome assistance, mainly in oral translation, has been iven to other governmental bodies and scientific orkers. Some work has been sent to outside transla- ors, mainly in Japanese, which is not covered by the ection, but also in other languages, owing to tem- orary shortage of staff.

Translated contents lists have been prepared from ussian scientific and technical periodicals, both for the ssistance of research staff and for inclusion in the *Translated Contents Lists of Russian Periodicals* issued by the Department of Scientific and Industrial Research of Great Britain. Copies of the D.S.I.R. Lists are sold by H.M. Stationery Office.

The Section has acted as Australian agent for the Index of Translations of the British Commonwealth Scientific Office. A reference card index of available translations has been kept and its existence advertised. The use made of it has not been extensive.

The languages handled by the Translation Section are German, Dutch, Swedish, Norwegian, Danish, Icelandic, Latin, French, Italian, Spanish, Portuguese, Hebrew, Russian, Polish, Ukranian, and Lettish. For other languages, use is made of a panel of outside translators.

7. INFORMATION AND DOCUMENTATION.

The policy of decentralizing information work in the Organization has been continued and during the year under review the Information Section has been discontinued as a separate staff. Its former staff, which is now attached to the Secretariat, is responsible for dealing with inquiries which cannot be handled by Divisions and Sections or other specialist bodies, and for providing information and intelligence for the Executive. The Documentation Section is now attached to the Library.

8. OVERSEAS LIAISON OFFICES.

The Organization maintains Scientific Liaison Offices in London and Washington as constituent units of the British Commonwealth Scientific Office (London) and the British Commonwealth Scientific Office (North America). These offices maintain close contact with overseas scientific developments and also act as bases for C.S.I.R.O. visitors and research students and other visiting scientists.

XXXIII. PERSONNEL OF COUNCIL AND COMMITTEES.

1. EXECUTIVE.

I. Clunies Ross, D.V.Sc. (*Chairman*).
F. W. G. White, M.Sc., Ph.D. (*Chief Executive Officer*).
S. H. Bastow, D.S.O., B.Sc., Ph.D.
H. J. Goodes, B.A.
A. B. Ritchie, M.A.

2. ADVISORY COUNCIL.

Chairman.

I. Clunies Ross, D.V.Sc.

Executive.

(*See* above.)

Chairmen of State Committees.

New South Wales—Professor J. P. Baxter, O.B.E., B.Sc., Ph.D.
Victoria—R. S. Andrews, D.Sc.
Queensland—A. F. Bell, M.Sc., D.I.C.
South Australia—Professor J. G. Wood, Ph.D., D.Sc.
Western Australia—Professor E. J. Underwood, B.Sc. (Agric.), Ph.D.
Tasmania—S. L. Kessell, M.B.E., M.Sc.

Co-opted Members.

D. T. Boyd, C.M.G.
Sir Macfarlane Burnet, M.D., Ph.D., F.R.S.
The Hon. O. McL. Falkiner, M.L.C.
W. A. Gunn.
E. H. B. Lefroy.
D. Mackinnon.
I. M. McLennan, B.E.E.
Emeritus Professor Sir John Madsen, B.E., D.Sc.
Professor L. H. Martin, Ph.D.
Professor D. M. Myers, B.Sc., D.Sc., Eng.

Professor M. L. Oliphant, M.A., Ph.D., D.Sc., LL.D., F.R.S.
G. B. O'Malley, B.Met.E.
Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S.
Professor S. M. Wadham, M.A.

3. State Committees.

New South Wales.

Professor J. P. Baxter, O.B.E., B.Sc., Ph.D. (*Chairman*).
Emeritus Professor Sir Henry Barraclough, K.B.E., V.D., B.E., M.M.E.
F. S. Bradhurst.
V. J. F. Brain, B.E.
J. N. Briton, B.Sc., B.E.
Sir Harry Brown, C.M.G., M.B.E.
Professor H. R. Carne, D.V.Sc.
S. F. Cochran.
The Hon. O. McL. Falkiner, M.L.C.
W. R. Hebblewhite, B.E.
E. L. S. Hudson.
The Hon. Sir Norman Kater, M.L.C., M.B., Ch.M.
J. F. Litchfield.
Professor P. R. McMahon, M.Agr.Sc., Ph.D.
Sir Frederick McMaster.
Professor J. R. A. McMillan, D.Sc.Agr., M.S.
Emeritus Professor Sir John Madsen, B.E., D.Sc.
J. Merrett.
C. St. J. Mulholland, B.Sc.
Professor D. M. Myers, B.Sc., D.Sc.Eng.
R. J. Noble, B.Sc.Agr., M.Sc., Ph.D.
R. P. Okeden.
J. G. Peake.
A. R. Penfold.
Professor D. W. Phillips, B.Sc., Ph.D.
H. F. Prell.
L. A. Pockley, B.V.Sc.
T. C. Roughley, B.Sc.
J. P. Tivey, B.A., B.Sc., B.E.
J. Vernon, B.Sc., Ph.D.
Emeritus Professor W. L. Waterhouse, M.C., D.Sc.Agr., D.I.C.
Emeritus Professor R. D. Watt, M.A., B.Sc.
C. M. Williams.

Victoria.

R. S. Andrews, D.Sc. (*Chairman*).
D. T. Boyd, C.M.G.
N. K. S. Brodribb, C.B.E.
Sir Macfarlane Burnet, M.D., Ph.D., F.R.S.
J. R. S. Cochrane, B.Sc.
Sir Herbert Gepp.
Professor J. N. Greenwood, D.Sc., M.Met.E.
Sir Russell Grimwade, C.B.E., B.Sc.
Professor E. J. Hartung. D.Sc.
H. Herman, D.Sc., M.M.E., B.C.E.
Professor E. S. Hills, D.Sc., Ph.D., D.I.C.
R. A. Hunt, D.S.O., B.C.E.
Associate Professor G. W. Leeper, M.Sc.
Emeritus Professor Sir Peter MacCallum, M.C., M.A., M.Sc., M.B., Ch.B.
I. M. McLennan, B.E.E.
H. A. Mullett, B.Agr.Sc.
G. B. O'Malley, B.Met.E.
Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S.
D. E. Thomas, D.Sc.
Professor J. S. Turner, M.A., Ph.D., M.Sc.
Professor S. M. Wadham, M.A.
W. E. Wainwright.
L. J. Weatherley, M.A.
Emeritus Professor H. A. Woodruff, B.Sc.

Queensland.

A. F. Bell, M.Sc., D.I.C. (*Chairman*).
R. J. Donaldson, D.S.O., B.C.E.
J. R. Duggan, B.Sc., B.E.
Professor T. K. Ewer, B.V.Sc., Ph.D.
V. Grenning.
W. A. Gunn.
R. L. Harrison.
Professor D. A. Herbert, D.Sc.
C. H. Jamieson.
N. J. King.
A. McCulloch, M.E.
Professor W. V. Macfarlane, M.A., M.D., Ch.B.
J. F. Meynink.
J. Michelmore.
I. W. Morley, B.M.E., B.Met.E.
O. E. J. Murphy, M.D., M.Ch.M.
Professor M. Shaw, M.E., M.Mech.E.
B. Flewell-Smith.
Professor W. Stephenson, B.Sc., Ph.D.
W. A. T. Summerville, D.Sc.
Professor L. J. H. Teakle, B.Sc.Agr., M.S., Ph.D.
S. A. Trout, M.Sc., Ph.D.
H. C. Urquhart, M.Sc.
R. Veitch, B.Sc.Agr., B.Sc.For.
Professor H. C. Webster, D.Sc., Ph.D.
W. Webster, B.V.Sc.
Professor F. T. M. White, B.Met.E., B.E.
M. White. M.Sc., Ph.D.
Associate Professor F. W. Whitehouse, D.Sc., Ph.D.
W. Young.

South Australia.

Professor J. G. Wood, Ph.D., D.Sc. (*Chairman*).
A. J. Allen.
B. H. Bednall, B.Sc.
A. R. Callaghan, C.M.G., B.Sc., B.Sc.Agr., D.Phil.
Professor D. G. Catcheside, M.A., D.Sc., F.R.S.
S. B. Dickinson, M.Sc.
Emeritus Professor Sir Kerr Grant, M.Sc.
C. Haselgrove.
J. C. Hawker, B.A.
O. H. Heinrich.
Professor L. G. H. Huxley, M.A., D.Phil.
W. S. Kelly, O.B.E.
R. N. McCulloch, M.B.E., D.Sc.(Agr.), B.Sc.
H. R. Marston, F.R.S.
Emeritus Professor Sir Douglas Mawson, O.B.E., D.Sc. B.E., F.R.S.
Professor M. L. Mitchell, M.Sc.
F. W. Moorhouse, M.Sc.
F. T. Perry, M.B.E.
Professor J. A. Prescott, C.B.E., D.Sc., F.R.S.
Professor E. A. Rudd, A.M., B.Sc.
W. L. Sanderson, O.B.E., M.C., C.de G.
E. M. Schroder.
A. M. Simpson, B.Sc.
Professor E. C. R. Spooner, B.E., D.Sc., D.Phil.

Western Australia.

Professor E. J. Underwood, B.Sc.(Agr.), Ph.D (*Chairman*).
Professor N. S. Bayliss, B.A., B.Sc., Ph.D.
H. Bowley.
F. G. Brinsden.
D. W. Brisbane.
C. R. Bunning, B.C.E.
Professor C. J. Birkett Clews, B.Sc., Ph.D.
Professor K. L. Cooper, B.Sc., M.A.
A. J. Fraser.
B. J. Grieve, M.Sc., Ph.D.
P. H. Harper, B.A.
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C. K. Vears, B.Sc.Agr., Department of Agriculture, New South Wales.
R. Roe, B.Sc.(Agric.), Division of Animal Health and Production, C.S.I.R.O.
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G. E. Forster, Graziers' Association of New South Wales.
H. F. White, Graziers' Association of New South Wales.
A. W. Weller, Northern New South Wales Farmers' Union.
L. P. Dutton, Council of Advice to the Pasture Protection Board, New South Wales.
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. B. Kelley, D.V.Sc., Division of Animal Health and Production, C.S.I.R.O.

. A. T. Summerville, D.Sc., Department of Agriculture and Stock, Queensland.

. Webster, B.V.Sc., Department of Agriculture and Stock, Queensland.

. H. S. Dolling, B.Agr.Sc., Division of Animal Health and Production, C.S.I.R.O. (*Secretary*).

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W. Webster, B.V.Sc., Department of Agriculture and Stock, Queensland.

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17. Advisory Committee on Fruit Cool Storage Investigations in New South Wales.

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W. G. White, M.Sc., Ph.D., C.S.I.R.O.
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G. Nicholls, M.Sc., C.S.I.R.O. (*Conjoint ecretary*).
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oup Captain J. W. Reddrop, R.A.A.F., Director of Telecommunications and Radar, Department of Air.
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fessor L. G. H. Huxley, M.A., D.Phil., University f Adelaide.
P. Chippindall, Postmaster-General's Department.
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Loewe, Ph.D., University of Melbourne.
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Stewart, B.E., Australian National Airways Ltd.
E. Coate, Australian National Airlines Commission.
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Captain N. K. J. Felstead, Australian Air Pilots' Association.
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W. Engeman, Telecommunications Advisory Committee.
A. H. Kaye, B.Sc., Telecommunications Advisory Committee.
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D. J. Medley, M.Sc., Department of Civil Aviation.
J. L. Mulholland, Overseas Telecommunications Commission (Australia).
C. H. Munro, D.Sc., Radio Research Board, C.S.I.R.O.
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E. J. Stewart, Postmaster-General's Department.
E. P. Wright, B.Sc., Postmaster-General's Department.
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G. B. Gresford, B.Sc., A.M.T.C., C.S.I.R.O. (*Joint Secretary*).
B. E. Mummery, B.Sc., C.S.I.R.O. (*Joint Secretary*).

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J. W. Drysdale, Commonwealth Experimental Building Station, Sydney.
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M. Beard, B.Sc., B.E., Division of Radiophysics, C.S.I.R.O. (*Secretary*).

XXXIV. STAFF.

The following is a list of the staff of the Organization as at 30th June, 1953. The list does not include clerical staff, typists, technical assistants, and miscellaneous workers.

1. Head Office.

(Head-quarters: 314 Albert-street, East Melbourne.)
Chairman—I. Clunies Ross, D.V.Sc.
Chief Executive Officer—F. W. G. White, M.Sc., Ph.D.
Executive Officer—S. H. Bastow, D.S.O., B.Sc., Ph.D.
Assistant Executive Officer—H. C. Forster, M.Agr.Sc., Ph.D.
Secretary (General Administration)—F. G. Nicholls, M.Sc.
Secretary (Industrial and Physical Sciences)—G. B. Gresford, B.Sc., A.M.T.C.
Secretary (Agricultural and Biological Sciences)—W. Ives, M.Ec.
Secretary (Finance and Supplies)—M. G. Grace, A.A.S.A.
Assistant Secretary (General Administration)—D. T. C. Gillespie, M.Sc.
Senior Research Officer—W. F. Evans, B.Sc.
Senior Research Officer—J. F. H. Wright, B.Sc.
Research Officer—P. F. Butler, M.Sc.Agr.
Research Officer—Miss J. Dunstone, B.Sc., Dip.Ed.
Research Officer—B. E. Mummery, B.Sc.
Research Officer—J. A. Ramsay, M.Sc.
Research Officer—G. J. Walker, M.Sc.

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Editor—N. S. Noble, D.Sc.Agr., M.S., D.I.C.
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Research Officer—R. W. Crabtree, B.Sc.
Research Officer—Miss L. F. Plunkett, B.Sc.
Research Officer—Miss M. Walkom, B.A.
Research Officer—G. J. Wylie, B.A., B.Sc.

Library—
Chief Librarian—Miss E. Archer, M.Sc.
Librarian—Miss F. V. Murray, M.Sc.
Librarian—Miss J. Conochie, B.Sc.
Librarian—Miss B. C. L. Doubleday, M.A.
Librarian—Miss I. J. McPhail, B.Sc. (at Brisbane).
Librarian—Miss L. J. Davey, B.Sc.
Librarian (Union Catalogue of Periodicals)—Miss A. L. Kent.

Accounts, Finance, Stores—
Accountant—D. J. Bryant, A.A.S.A.
Finance Officer—R. W. Viney, A.A.S.A., A.C.I.S.
M. A. Elliott.

Orders and Transport—
J. M. Derum.

Staff—
Staff and Industrial Officer—H. E. Waterman, A.A.S.A.
R. D. Elder.

Records—
P. Knuckey.

Publications—
Senior Technical Officer—T. R. Hunter.
Senior Technical Officer—J. D. Chamberlain.
Technical Officer—Miss M. Crellin.

Central Experimental Workshops—
Electrical and Mechanical Engineer—R. N. Morse B.Sc., B.E.
Engineer-in-charge—F. G. Hogg, B.E.
Research Officer—J. Kowalczewski, Dipl.Ing.
Research Officer—R. Medding, B.E.E.
Research Officer—I. P. Arthur, B.Mech.Eng.
Plant Engineer—K. A. Robeson, B.Mech.Eng.
Chief Draughtsman—G. T. Stephens, Dip.Mech.Eng. Dip.Elec.Eng.
Draughtsman, Grade II.—F. Wickham, Dip.Mech Eng.
Draughtsman, Grade II.—J. R. Mitchell, Dip.Mech Eng., Dip.Elec.Eng.
Draughtsman, Grade II.—W. J. Fatchen, Dip.Mech Eng., Dip.Elec.Eng.
Draughtsman, Grade II.—W. R. Read.

Liaison Overseas—
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Chief Scientific Liaison Officer, J. E. Cummins B.Sc., M.S.
Senior Research Officer — A. B. Hackwell B.Agr.Sc.
Research Officer—N. M. Tulloh, M.Agr.Sc.
Washington—
Principal Research Officer—E. J. Drake.
Research Officer—A. F. Gurnett-Smith, B.Agr.Sc. Q.D.D.

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Translator—E. Feigl, Ph.D.
Translator—Mrs. M. Slade.
Translator—H. E. Kylstra, B.A.
Translator—C. Wouters, D. ès L. (at Sydney).

Film Unit—
Research Officer—S. T. Evans, B.Sc.
Technical Officer—L. A. Doogood.

Architectural—
Architect—W. R. Ferguson, B.E.
Buildings Officer—L. H. Mosman (at Sydney).
Draughtsman, Grade II.—W. J. Widdowson.

2. Secretaries of State Committees.

New South Wales—
A. M. Andrews, B.Sc., First Floor, Wall House, 1 Loftus-street, Sydney.

Victoria—
F. G. Nicholls, M.Sc., 314 Albert-street, East Melbourne.

Queensland—
Miss H. F. Todd, 113 Eagle-street, Brisbane.

South Australia—
A. Packham, B.V.Sc., Division of Biochemistry an General Nutrition, University of Adelaide.

Western Australia—
R. P. Roberts, M.Sc.(Agric.), Department of Agriculture, Perth.

Tasmania—
D. Martin, B.Sc., "Stowell", Stowell-avenu Hobart.

3. Agricultural Research Liaison Section.

(Head-quarters: 314 Albert-street, East Melbourne.
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Senior Research Officer—K. Loftus Hills, M.Agr.Sc.
Senior Research Officer—T. C. Bell, B.Agr.Sc.
Research Officer—A. F. Gurnett-Smith, B.Agr.Sc Q.D.D. (seconded).
Research Officer—Miss J. M. Baldwin, B.Sc., Dip.Ec
Technical Officer—E. A. Jennings, B.Agr.Sc.
Technical Officer—L. H. Kelly.

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(Head-quarters: University of Sydney.)

er-in-charge—J. M. Rendel, B.Sc., Ph.D.
ior Research Officer—A. S. Fraser, M.Sc., Ph.D.
earch Officer—D. F. Dowling, B.V.Sc., B.Sc., Ph.D.
earch Officer—W. R. Sobey, Ph.D.

. DIVISION OF ANIMAL HEALTH AND PRODUCTION.

ead-quarters: Cr. Flemington-road and Park-street, Parkville, Melbourne.)

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Assistant Divisional Secretary—N. M. Tulloh, M.Agr.Sc. (seconded to A.S.L.O., London).
Acting Assistant Divisional Secretary—A. B. Cashmore, B.Sc.(Agric.), M.Sc.

Animal Health Research Laboratory, Melbourne—

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Principal Research Officer—D. Murnane, D.V.Sc.
Principal Research Officer—R. H. Watson, D.Sc.Agr.
Principal Research Officer—A. T. Dick, M.Sc.
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t Field Station, Merbein, Victoria—

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Technical Officer—L. C. Gamble.

Poultry Breeding Investigations—

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Research Officer—J. A. Morris, B.Sc.Agr. (on study leave).
Research Officer—B. L. Sheldon, B.Sc.Agr.
Research Officer—T. E. Allen, B.Sc.
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Technical Officer—Miss L. W. Böbr, M.Sc.(Agr.).

t McMaster Animal Health Laboratory, Sydney—

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Research Officer—R. I. Sommerville, M.Sc.Agr.
Research Officer—P. K. Briggs, B.Sc.Agr.
Research Officer—P. R. Whitfeld, B.Sc. (on study leave).
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Technical Officer—B. L. Campbell.
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Officer-in-charge, Sheep Biology Laboratory—C. W. Emmens, D.Sc., Ph.D. (part-time).
Research Officer—J. P. Hogan, B.Sc.Agr.

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Technical Officer—P. H. G. Sheaffe.

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At Western Australian Department of Agriculture, Animal Health and Nutrition Laboratory, Nedlands, Western Australia—

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At Institute of Agriculture, University of Western Australia, Nedlands, Western Australia—

Senior Research Officer—E. Munch-Petersen, M.Sc., B.A., M.I.F.

At Waite Agricultural Research Institute, Adelaide, South Australia—

Research Officer—G. W. Grigg, M.Sc.

6. Atomic Physics.

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Research Officer—A. M. Downes, M.Sc.
Research Officer—K. R. Lynn, B.Sc.

At Physics Department, University of Melbourne—

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Technical Officer—D. R. Ellis.

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Principal Research Officer—C. D. Boadle, B.M.E.
Senior Research Officer—J. N. Gregory, M.Sc.
Senior Research Officer—N. A. Faull, B.Sc.
Senior Research Officer—G. L. Miles, B.A., M.Sc., Ph.D.
Research Officer—D. F. Sangster, B.Sc.

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Senior Research Officer—F. V. Gray, M.Sc.
Senior Research Officer—Miss M. C. Dawbarn, M.Sc. (part-time).
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Senior Research Officer—I. G. Jarrett, M.Sc.
Senior Research Officer—G. B. Jones, M.Sc.
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Technical Officer—J. O. Wilson (part-time).
Technical Officer—D. F. Graham.
Technical Officer—C. E. Sleigh.
Technical Officer—R. F. Trowbridge.
Technical Officer—E. Talbot-Smith.
Technical Officer—Miss M. B. Hamilton, B.Sc.

8. Division of Building Research.

(Head-quarters: Graham-road, Highett, Victoria.)

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Technical Secretary—J. R. Barned, B.Sc.
Technical Officer—E. S. Smith.
Sectional Draughtsman—W. Maier, Dip.Ing.

Information and Library—

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Research Officer—Mrs. C. M. Petrie, M.A., Ph.D (part-time).
Senior Technical Officer—W. Brown, B.Sc.
Librarian—Mrs. S. A. Curwen.

Physical and Mechanical Testing Laboratory—

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Technical Officer—W. U. S. Falk, F.M.T.C.
Technical Officer—F. D. Beresford, F.M.T.C.
Technical Officer—J. J. Russell, B.Sc.

Concrete Investigations—

Research Officer—F. A. Blakey, B.E., Ph.D.
Principal Technical Officer—W. H. Taylor M.C.E.
Technical Officer—E. N. Mattison.
Technical Officer—I. Leber, Dip.Ing.

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Senior Research Officer—H. V. Hueber, Dr.Phil
Senior Research Officer—W. F. Cole, M.Sc. Ph.D.
Research Officer—J. A. Ferguson, M.Sc., Ph.D.
Research Officer—R. D. Hill, B.Sc., B.Com.
Research Officer—Mrs. T. Demediuk, Dr.Phil.
Technical Officer—A. R. Carthew, B.Sc.
Technical Officer—Miss M. E. Neilson, B.Sc.
Technical Officer—A. E. Holland, A.M.T.C.
Technical Officer—D. N. Crook, A.Sw.T.C.
Technical Officer—Miss A. Feldman.

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Research Officer—J. E. Bright, B.Sc.
Technical Officer—D. A. Powell, B.Sc.
Technical Officer—I. D. McLachlan.

Acoustics and Thermal Investigations—

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Senior Research Officer—W. K. R. Lippert Dr.Phil.
Research Officer—A. F. B. Nickson, M.Sc.
Research Officer—T. S. Holden, B.Sc.
Technical Officer—A. W. Wilson.
Technical Officer—Miss V. R. Goullet, B.Sc.
Technical Officer—P. Dubout, B.Sc.

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Senior Research Officer—B. M. Holmes, M.Sc.
Research Officer—E. R. Ballantyne, B.Sc.
Technical Officer—N. G. Brown, A.M.T.C.
Technical Officer—J. W. Spencer, B.Sc.

9. COAL RESEARCH SECTION.

(Head-quarters: Delhi-road, North Ryde, New South Wales.)

dministration and General—

Officer-in-charge—H. R. Brown, B.Sc.(Eng.).
Technical Secretary—A. M. Andrews, B.Sc.
Librarian—Miss R. Souhami, B.Sc.

hemical Properties—

Principal Research Officer—H. Berry, M.Sc. (Tech.).
Research Officer—H. N. S. Schafer, B.Sc.
Senior Technical Officer—M. S. Burns.
Technical Officer—W. O. Stacy, B.Sc.
Technical Officer—Mrs. B. J. Nivison-Smith, B.Sc.
Technical Officer—T. P. Maher, B.Sc.
Technical Officer—A. J. Ryan, B.Sc.

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Technical Officer—J. W. Smith, A.R.I.C.
Technical Officer—J. Szewczyk, M.Phys., Dipl. Ing.Chem.
Technical Officer—Miss R. G. Loomes, A.S.T.C.

hysical Chemistry—

Senior Research Officer—J. D. Brooks, B.Sc.
Research Officer—M. Kossenberg, Ph.D.
Research Officer—A. G. Parts, M.Ch., Ph.D.
Technical Officer—Mrs. A. J. Collins, A.S.T.C.

ombustion and Physical Testing—

Senior Research Officer—N. Y. Kirov, M.Sc.
Technical Officer—G. à Donau Szpindler, Dipl. Ing., D.I.C.
Technical Officer—W. Pitkeathly, B.E.(Chem.).

arbonization—

Senior Research Officer—G. B. Howart, M.C., M.Sc. (seconded from Joint Coal Board).
Research Officer—R. H. Jones, B.Sc.
Technical Officer—J. T. Munday, B.E.(Chem.).
Technical Officer—A. Wlasow, Dipl.Chem., Dipl. Ing.

Petrography—

Research Officer—B. E. Balme, B.Sc.
Technical Officer—J. P. F. Hennelly, B.Sc.

10. COMMONWEALTH RESEARCH STATION (MURRAY IRRIGATION AREAS).

(Head-quarters: Merbein, Victoria.)

Officer-in-charge—F. Penman, M.Sc.
Principal Research Officer—G. L. Amos, M.Sc.
Senior Research Officer—J. G. Baldwin, B.Agr.Sc., B.Sc.
Research Officer—G. V. F. Clewett, B.E.
Research Officer—W. J. Webster, B.Sc.
Research Officer—A. J. Antcliff, B.Sc.
Research Officer—M. R. Sauer, B.Agr.Sc.
Research Officer—S. F. Bridley, B.Agr.Sc.
Research Officer—R. C. Woodham, B.Agr.Sc.
Research Officer—D. McE. Alexander, B.Sc.
Senior Technical Officer—J. E. Giles.
Technical Officer—G. L. Stott, A.S.T.C.
Technical Officer—S. A. Giddings, B.Sc.
District Officer (Nyah-Woorinen)—R. C. Polkinghorne (part-time).
District Officer (Wakool)—H. Jackson (part-time).
District Officer (Renmark)—J. V. Seekamp, B.Agr.Sc. (part-time).

11. DAIRY RESEARCH SECTION.

(Head-quarters: Lorimer-street, Fishermen's Bend, Victoria.)

Officer-in-charge—G. Loftus Hills, B.Agr.Sc.
Principal Research Officer—N. King, M.Sc.
Senior Research Officer—E. G. Pont, M.Sc.Agr.
Senior Research Officer—K. Kumetat, Ph.D.
Senior Research Officer—J. Conochie, B.Sc.(Agric.).
Research Officer—A. J. Lawrence, B.Sc.
Research Officer—D. A. Forss, M.Sc.
Research Officer—J. Czulak, B.Sc.(Agric.), Dip.Bact.
Research Officer—J. W. Lee, B.Sc.
Technical Officer—R. Beeby, A.M.T.C.

12. DIVISION OF ELECTROTECHNOLOGY.

(Head-quarters: National Standards Laboratory at University of Sydney.)

Chief—F. J. Lehany, M.Sc.
Technical Secretary—R. C. Richardson, B.E.
Principal Research Officer—W. K. Clothier, B.Sc., M.E.
Principal Research Officer—A. M. Thompson, B.Sc.
Senior Research Officer—R. J. Meakins, B.Sc., Ph.D., D.I.C.
Senior Research Officer—L. G. Dobbie, M.E.
Senior Research Officer—B. V. Hamon, B.Sc., B.E.
Senior Research Officer—D. L. Hollway, B.E.E., M.Eng.Sc.
Research Officer—J. S. Dryden, M.Sc., Ph.D., D.I.C.
Research Officer—J. J. O'Dwyer, B.Sc., B.E., Ph.D.
Research Officer—T. M. Palmer, Dipl.F.H.
Research Officer—G. J. A. Cassidy, B.E.E.
Research Officer—D. L. H. Gibbings, B.E., B.Sc., Ph.D.
Research Officer—D. W. Posener, M.Sc. (abroad).
Research Officer—H. K. Welsh, M.Sc.
Research Officer—G. J. Johnson, B.Sc.
Research Officer—D. G. Lampard, M.Sc. (abroad).
Research Officer—Mrs. P. Arnold, A.S.T.C.
Research Officer—W. E. Smith, B.Sc.
Principal Technical Officer—L. Medina, Dipl.Ing.
Senior Technical Officer—L. M. Mandl, Dipl.Ing., A.S.T.C.
Senior Technical Officer—F. C. Brown, A.S.T.C.
Senior Technical Officer—H. A. Smith, A.S.T.C.
Technical Officer—R. W. Archer, A.S.T.C.
Technical Officer—E. Cowcher, B.A., A.S.T.C.
Technical Officer—H. C. Collins, A.S.T.C.
Technical Officer—J. M. Melano, A.S.T.C.
Technical Officer—M. C. McGregor, A.S.T.C.
Technical Officer—K. M. Goodson, B.Sc.
Technical Officer—F. C. Hawes, A.S.T.C.
Technical Officer—J. S. Cook, B.Sc.
Technical Officer—R. E. Holmes, A.S.T.C.
Technical Officer—N. L. Brown, A.S.T.C.
Technical Officer—R. P. Hoffman.
Technical Officer—I. K. Harvey, A.S.T.C.
Technical Officer—H. Bairnsfather.
Technical Officer—R. V. Single.

13. DIVISION OF ENTOMOLOGY.

(Head-quarters: Canberra, A.C.T.)

At Canberra—

Administration—

Chief—A. J. Nicholson, D.Sc.
Assistant Chief—D. F. Waterhouse, D.Sc.
Technical Secretary—K. L. Taylor, B.Sc.Agr.
Librarian—Miss J. Humphreys, B.A., Dip.Ed. (half-time).
Chief Clerk—K. J. Prowse (half-time).
Deputy Chief Clerk—D. W. Banyard (half-time).
Accountant—L. J. Peres, B.Ec. (half-time).
Technical Officer—L. A. Marshall.
Technical Officer—D. H. Wilson.
Technical Officer—W. J. Rafferty.

Biological Control—
Principal Research Officer—F. Wilson.
Research Officer—E. F. Riek, M.Sc.
Technical Officer—G. R. Wearne.

Museum—
Research Officer—T. G. Campbell.

Taxonomy of Diptera—
Senior Research Officer—S. J. Paramonov, D.Sc.

Physiology and Toxicology—
Principal Research Officer—D. F. Waterhouse, D.Sc.
Senior Research Officer—D. Gilmour, M.Sc. (abroad).
Research Officer—R. F. Powning, M.Sc., A.S.T.C.
Research Officer—R. H. Hackman, M.Sc., Ph.D.
Technical Officer—L. G. Webber, B.Sc.
Technical Officer—H. Irzykiewicz.
Technical Officer—Miss M. Lazarus, B.Sc.
Technical Officer—Mrs. M. M. Goldberg, B.Sc.

Insecticide Investigations—
Research Officer—R. W. Kerr, B.Sc.

Locust and Grasshopper Investigations—
Principal Research Officer—K. H. L. Key, D.Sc.
Research Officer—P. B. Carne, B.Agr.Sc. (on study leave).
Technical Officer—L. J. Chinnick, R.D.A.

Cockchafer Investigations—
Research Officer—P. B. Carne, B.Agr.Sc. (on study leave).

Virus Vector Investigations—
Senior Research Officer—M. F. Day, B.Sc., Ph.D.
Research Officer—A. L. Dyce, B.Sc.Agr.
Technical Officer—N. E. Grylls, D.D.A.

Termite Investigations—
Senior Research Officer—F. J. Gay, B.Sc., D.I.C.
Technical Officer—A. Wetherley.

Ant Investigations—
Research Officer—T. Greaves.

Population Dynamics—
Chief of Division—A. J. Nicholson, D.Sc.
Senior Technical Officer—A. T. Mills.
Technical Officer—S. Dee.

Field Population Studies—
Senior Research Officer—L. R. Clark, M.Sc.

Pasture Caterpillar Investigations—
Senior Research Officer—I. F. B. Common, M.A., M.Agr.Sc.

Stored Products Pests Investigations—
Research Officer—S. W. Bailey, B.Sc., A.R.C.S.

At Yeerongpilly, Queensland—
Cattle Tick Investigations—
Senior Research Officer—K. R. Norris, M.Sc.
Research Officer—W. J. Roulston, B.Sc.
Technical Officer—R. A. J. Meyers, Q.D.A.H., Q.D.D.

At Rockhampton, Queensland—
Cattle Tick Investigations—
Research Officer—P. R. Wilkinson, M.A.
Technical Officer—J. T. Wilson, Q.D.A.

At Nedlands, Western Australia—
Earth Mite and Lucerne Flea Investigations—
Research Officer—M. M. H. Wallace, B.Sc.
Technical Officer—J. A. Mahon, Dip.D.Sci.

At Sydney—
Biological Control—
Research Officer—G. J. Snowball, B.Sc.
Technical Officer—J. Citowitsch, Dip.Biol.

14. DIVISION OF FISHERIES.

(Head-quarters: Cronulla, N.S.W.)

At Cronulla—
Chief—H. Thompson, M.A., D.Sc.
Technical Secretary—Mrs. L. M. Willings, B.A.
Senior Research Fellow—L. G. M. Baas Becking, Ph.D., D.Sc.
Senior Principal Research Officer—G. W. Rayner, M.Sc.
Principal Research Officer—E. J. Ferguson Wood, B.A., M.Sc.
Senior Research Officer—M. Blackburn, D.Sc.
Senior Research Officer—D. J. Rochford, B.Sc.
Research Officer—I. S. R. Munro, M.Sc.
Research Officer—J. M. Thomson, M.Sc. (abroad).
Research Officer—A. M. Rapson, M.Sc.
Research Officer—R. S. Spencer, B.Sc.
Research Officer—Miss P. Kott, M.Sc.
Research Officer—T. W. Houston, B.Sc.
Senior Technical Officer—A. Proctor.
Technical Officer—J. P. Robins, B.Sc.
Technical Officer—D. Thompson, Dip. Applied Chem.
Technical Officer—Miss B. B. Dew, B.A.
Technical Officer—F. E. Allen.
Technical Officer—G. A. Gordon.

At Melbourne—
Technical Officer—P. E. Gartner, B.Sc.

At Perth—
Research Officer (Officer-in-charge)—K. Sheard, M.Sc.
Research Officer—W. B. Malcolm, B.Sc.
Research Officer—R. G. Chittleborough, B.Sc.
Research Officer—R. W. George, B.Sc.
Technical Officer—H. R. Jitts, B.Sc.
Technical Officer—A. Middleton, Dip.Chem.

At Hobart—
Senior Research Officer—A. G. Nicholls, B.Sc., Ph.D.
Research Officer—A. M. Olsen, M.Sc.
Research Officer—A. H. Weatherley, B.Sc.
Research Officer—T. R. Cowper, B.Sc.
Technical Officer—A. B. Jack, B.Sc.

At Dunwich, Queensland—
Research Officer—G. S. Grace, B.Sc.
Technical Officer—D. J. Dunstan, B.Sc.

At Thursday Island, Queensland—
Research Officer—J. S. Hynd, B.Sc.
Technical Officer—D. J. Tranter, B.Sc.

15. DIVISION OF FOOD PRESERVATION AND TRANSPORT.

(Head-quarters: State Abattoir, Homebush Bay, New South Wales.)

At Homebush, New South Wales—
Administration and General—
Chief—J. R. Vickery, M.Sc., Ph.D.
Technical Secretary—R. B. Withers, M.Sc., Dip.Ed.
Technical Officer—Miss E. M. Christie, B.Sc.
Librarian—Miss B. Johnston, B.Sc.
Physics and Transport Section—
Principal Research Officer—E. W. Hicks, B.A., B.Sc.
Senior Research Officer—M. C. Taylor, M.Sc.

Research Officer—G. M. Rostos, Dipl.Ing.
Research Officer—H. L. Evans, M.Sc.
Technical Officer—J. D. Mellor.
Technical Officer—Miss J. A. Hiscox, B.Sc.

Microbiology Section—

Principal Research Officer—W. J. Scott, B.Agr.Sc.
Research Officer—M. R. J. Salton, B.Sc.Agr., Ph.D. (abroad).
Research Officer—W. G. Murrell, B.Sc.Agr., D.Phil.
Research Officer—J. H. B. Christian, B.Sc.Agr.
Senior Technical Officer—D. F. Ohye, D.I.C.
Technical Officer—P. R. Maguire.
Technical Officer—Miss B. J. Marshall, A.S.T.C.

Biochemistry—

Principal Research Officer—F. E. Huelin, B.Sc., Ph.D.
Research Officer—J. B. Davenport, M.Sc.

Organic Chemistry—

Senior Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil.
Research Officer—A. S. F. Ash, B.Sc., Ph.D.
Research Officer—E. F. L. J. Anet, M.Sc., Ph.D.

Fruit and Vegetable Storage Section—

Senior Research Officer—E. G. Hall, B.Sc.Agr.
Research Officer—J. F. Turner, M.Sc. (abroad).
Research Officer—Miss J. M. Bain, M.Sc.
Technical Officer—T. J. Riley, H.D.A.
Technical Officer—J. A. Casey, A.M.T.C.

Canning and Fruit Products Section—

Principal Research Officer—L. J. Lynch, B.Agr.Sc. (abroad).
Principal Research Officer—J. F. Kefford, M.Sc.
Senior Research Officer—R. S. Mitchell, M.Sc.Agr. (abroad).
Research Officer—B. V. Chandler, B.Sc.
Research Officer—E. G. Davis, B.Sc.
Research Officer—P. W. Board, B.Sc.
Technical Officer—G. A. Harris, A.S.T.C.

Dried Foods Section—

Research Officer—D. McG. McBean, B.Sc.
Technical Officer—F. Fitzpatrick, A.S.T.C.

Fish Preservation Investigations—

Principal Research Officer—W. A. Empey, B.V.Sc.
Technical Officer—R. Allan.

Meat and Egg Investigations—

Chief—J. R. Vickery, M.Sc., Ph.D.
Senior Research Officer—A. R. Riddle, A.B., M.S.
Technical Officer—F. S. Shenstone, A.S.T.C.

Freezing of Fruit and Vegetables—

Research Officer—I. J. Tinsley, B.Sc.

At Auburn, New South Wales—

Meat Dehydration Investigations—

Research Officer—A. R. Prater, B.Sc.Agr.

At Botany School, University of Sydney—

Plant Cell Physiology Investigations—

Principal Research Officer—R. N. Robertson, B.Sc., Ph.D.
Senior Research Officer—H. S. McKee, B.A., D.Phil.
Research Officer—Miss M. Wilkins, M.Sc.
Research Officer—Mrs. J. Pearson, M.Sc.
Research Officer—A. B. Hope, B.Sc., Ph.D.
Technical Officer—Mrs. L. Nesztel, B.Sc.

At Botany School, University of Melbourne—

Plant Cell Physiology Investigations—

Research Officer—K. S. Rowan, M.Sc.
Technical Officer—Mrs. G. Urbach, M.Sc.

At Biochemistry School, University of Sydney—

Physical Chemistry Section—

Research Officer—H. A. McKenzie, M.Sc.
Research Officer—J. J. Macfarlane, B.Sc.
Technical Officer—M. B. Smith, A.S.A.S.M.

At Tasmanian Regional Laboratory, Hobart—

Canning and Fruit Products—

Technical Officer—R. A. Gallop, A.S.T.C.

Fish Preservation Investigations—

Technical Officer—K. W. Anderson, A.M.T.C.

At Brisbane—

Meat Investigations—

Officer-in-charge—A. Howard, M.Sc.
Senior Research Officer—G. Kaess, Dr.Ing.
Research Officer—A. D. Brown, M.Sc.
Technical Officer—N. T. Russell, D.I.C.
Technical Officer—P. E. Bouton, B.Sc.

With United Kingdom Ministry of Food—

Senior Research Officer—N. E. Holmes, B.E.E., M.Mech.E. (seconded).

With Commonwealth Department of Commerce and Agriculture, Sydney—

Research Officer — J. Shipton, B.Sc.Agr. (seconded).

16. DIVISION OF FOREST PRODUCTS.

(Head-quarters: 69 Yarra Bank-road, South Melbourne, Victoria.)

Administration—

Chief—S. A. Clarke, B.E.
Assistant to Chief—C. S. Elliot, B.Sc.
Assistant to Chief—H. E. Dadswell, D.Sc.
Technical Secretary—F. A. Priest, A.S.A.S.M.
Information Officer—A. P. Wymond, M.Sc.
Librarian—Miss M. I. Hulme.
Senior Technical Officer—L. Santer, Dip.Eng.
Technical Officer—P. J. Moglia, Dip.Mech.Eng.

Wood and Fibre Structure Section—

Senior Principal Research Officer—H. E. Dadswell, D.Sc.
Senior Research Officer—Miss M. M. Chattaway, M.A., B.Sc., D.Phil.
Senior Research Officer—H. D. Ingle, B.For.Sc.
Senior Research Officer—I. V. Newman, M.Sc., Ph.D.
Senior Research Officer—A. B. Wardrop, M.Sc., Ph.D.
Research Officer—P. R. Wilkinson, B.Sc.
Research Officer—W. E. Hillis, M.Sc., A.G.Inst. Tech.
Technical Officer—Miss M. F. Day, B.Sc.
Technical Officer—C. F. James, B.Sc.

Photography—

Technical Officer—W. G. Hastie.
Technical Officer—Miss A. M. Lightfoot.

Wood Chemistry Section—

Senior Principal Research Officer—W. E. Cohen, D.Sc.
Senior Research Officer—D. E. Bland, M.Sc.
Senior Research Officer—H. G. Higgins, B.Sc.
Research Officer—Miss J. F. Hobden, B.Sc.
Research Officer—A. von Koeppen, Dr.Ing.
Research Officer—R. C. McK. Stewart, B.Sc.
Research Officer—A. J. Watson, A.M.T.C.
Technical Officer—A. G. Charles.
Technical Officer—Miss D. R. Fraser, B.Sc.
Technical Officer—Miss F. M. Gatley, B.Sc.
Technical Officer—Miss V. Goldsmith, A.M.T.C.
Technical Officer—A. W. McKenzie, A.M.T.C.
Technical Officer—J. A. McPherson, B.Sc. (on leave).
Technical Officer—Miss G. Schwerin, B.Sc.
Technical Officer—Miss L. Sitzman, B.Sc.

Timber Physics Section—

Principal Research Officer—R. S. T. Kingston, B.Sc., B.E.
Research Officer—L. N. Clarke, B.Eng.Sci.
Research Officer—Miss K. E. Kelsey, B.Sc.
Technical Officer—L. D. Armstrong, A.M.T.C.
Technical Officer—N. C. Edwards, A.S.M.B.
Technical Officer—P. U. A. Grossman, Ph.A.Mr. (Praha).
Technical Officer—J. W. P. Nicholls, B.Sc.

Timber Mechanics Section—

Senior Research Officer—J. D. Boyd, M.C.E.
Senior Research Officer—N. H. Kloot, M.Sc.
Research Officer—R. G. Pearson, B.A., B.C.E.
Technical Officer—J. J. Mack, A.M.T.C.
Technical Officer—K. B. Schuster, A.M.T.C.

Timber Seasoning Section—

Principal Research Officer—G. W. Wright, M.E.
Senior Research Officer—J. W. Gottstein, B.Sc.
Research Officer—E. L. Ellwood, M.Sc.(For.) (abroad).
Research Officer—W. G. Kauman, B.Sc., A.M.T.C.
Senior Technical Officer—L. J. Brennan.
Technical Officer—G. S. Campbell.
Technical Officer—F. J. Christensen, A.M.T.C.
Technical Officer—H. D. Roberts.

Timber Preservation Section—

Principal Research Officer—N. Tamblyn, M.Sc. (Agr.).
Senior Research Officer—E. W. B. Da Costa, M.Agr.Sc.
Research Officer — G. N. Christensen, M.Sc. (abroad).
Research Officer—G. W. Tack, B.Agr.Sc.
Research Officer—Miss S. J. Wilson, M.Sc.
Senior Technical Officer—J. Beesley, B.Sc.(For.), Dip.For.
Senior Technical Officer—F. A. Dale, F.M.T.C.
Senior Technical Officer—N. E. M. Walters, B.Sc.
Technical Officer—T. E. H. Aplin, B.Sc.
Technical Officer—D. F. McCarthy, A.M.T.C.
Technical Officer—Mrs. N. Matters.
Technical Officer—A. Rosel.

Veneer and Gluing Section—

Senior Research Officer—A. Gordon, B.Sc.
Research Officer—K. F. Plomley, B.Sc.(Agr.).
Technical Officer—K. Hirst.

Timber Utilization Section—

Senior Principal Research Officer—R. F. Turnbull, B.E.
Research Officer—W. M. McKenzie, B.Sc.(For.).
Technical Officer—D. S. Jones, B.C.E.
Technical Officer—R. L. Cowling, Dip.Mech.Eng., Dip.E.E. (on leave).

Maintenance Section—

Senior Technical Officer—S. G. McNeil.

17. Division of Industrial Chemistry.

(Head-quarters: Lorimer-street, Fishermen's Bend, Victoria.)

Administration—

Chief—I. W. Wark, D.Sc., Ph.D.
Divisional Secretary—L. Lewis, B.Met.E.
Assistant Secretary—A. E. Scott, M.Sc.

Minerals Utilization Section—

Senior Principal Research Officer—R. G. Thomas, B.Sc.
Principal Research Officer—A. Walkley, B.A., D.Sc., Ph.D.
Principal Research Officer—A. W. Wylie, M.Sc., Ph.D.
Senior Research Officer—F. K. McTaggart, M.Sc.
Senior Research Officer—T. R. Scott, D.Sc., B.Ed.
Research Officer—R. C. Croft, M.Sc.
Research Officer—A. T. Duff, B.Sc.
Research Officer—P. M. J. Gray, B.Sc., A.R.S.M
Research Officer—J. H. Green, Ph.D., M.Sc.
Research Officer—I. E. Newnham, M.Sc.
Research Officer—E. S. Pilkington, A.S.T.C.
Research Officer—R. C. Vickery, D.Sc., Ph.D.
Research Officer—A. D. Wadsley, M.Sc.
Senior Technical Officer—H. R. Skewes, A.A.C.I
Technical Officer—Miss I. J. Bear, A.M.T.C.
Technical Officer—Miss F. R. C. Hodkinson A.M.T.C.

Cement and Ceramics Section—

Principal Research Officer—G. F. Walker, B.Sc. Ph.D.
Principal Research Officer—W. O. Williamson B.Sc., Ph.D. (abroad).
Senior Research Officer—H. E. Vivian, B.Sc.Agr
Part-time Officer—A. J. Gaskin, M.Sc.
Research Officer—K. M. Alexander, M.Sc., Ph.D
Research Officer—S. M. Brisbane, B.A., B.Sc. A.M.T.C.
Research Officer—G. M. Bruere, M.Sc.
Research Officer—H. Ellerton (at Bonython Research Laboratory, S.A. School of Mines Adelaide).
Research Officer—H. R. Samson, B.Sc., Ph.D.
Research Officer—J. H. Taplin, B.Sc.
Research Officer—L. S. Williams, D.Phil., B.E.
Senior Technical Officer—C. E. S. Davis, B.Sc.
Senior Technical Officer—K. Grant, B.Sc.
Senior Technical Officer—J. D. Wolfe.
Technical Officer—Miss M. Ball, B.Sc.
Technical Officer—R. W. Cox, F.M.T.C.
Technical Officer—P. J. Darragh, B.Sc. (a Bonython Research Laboratory, S.A. School o Mines, Adelaide).
Technical Officer—A. C. Frostick.
Technical Officer—R. R. Hughan.
Technical Officer—Miss B. C. Terrell, B.Sc.
Technical Officer—J. Wardlaw, B.Sc.
Technical Officer—J. H. Weymouth, B.Sc.

Foundry Sands Section—

Senior Research Officer—H. A. Stephens, B.Sc.
Technical Officer—P. W. Goad, A.M.T.C.
Technical Officer—A. N. Waterworth, A.H.T.C

Chemical Physics Section—

Senior Principal Research Officer—A. L. G. Ree D.Sc., Ph.D.
Principal Research Officer—A. Walsh, M.Sc.Tec (abroad).
Senior Research Officer—E. H. Mercer, B.Sc Ph.D. (abroad).
Senior Research Officer—J. L. Farrant, M.Sc.
Senior Research Officer—A. McL. Mathieso B.Sc., Ph.D.
Senior Research Officer—D. A. Davies, B.Sc.
Senior Research Officer—J. M. Cowley, M.Sc Ph.D.
Research Officer—J. D. Morrison, B.Sc., Ph.D.
Research Officer—A. J. C. Nicholson, M.Sc., Ph.I
Research Officer—J. B. Willis, M.Sc., Ph.D.
Research Officer—A. F. Moodie, B.Sc.
Research Officer—A. J. Hodge, B.Sc., Ph.D.
Research Officer—B. Dawson, M.Sc., Ph.D.
Research Officer—J. P. Shelton, M.Sc., A.B.S.M
Research Officer—C. Billington, B.A.
Research Officer—C. K. Coogan, M.Sc., Ph.D.
Research Officer—J. O. Cope, M.Sc., Ph.D.
Research Officer—J. Fridrichsons, M.Sc.
Research Officer—A. C. Hurley, M.A., B.Sc Ph.D.
Research Officer—A. F. Beecham, B.Sc.
Research Officer—J. C. Riviere, M.Sc. (on stud leave).

Research Officer—J. V. Sullivan, M.Sc. (at University of Western Australia, Perth).
Research Officer—N. S. Ham, M.Sc. (on study leave).
Research Officer—P. Goodman, M.Sc.
Research Officer—W. C. T. Dowell, M.Sc.
Research Officer—Miss L. Hulme, B.Sc.
Senior Technical Officer—W. G. Jones.
Senior Technical Officer—S. E. Powell.
Senior Technical Officer—G. F. H. Box.
Technical Officer—E. Cakanovskis, Dipl. Ing.
Technical Officer—F. B. Williams.

sical Chemistry Section—

Senior Principal Research Officer—K. L. Sutherland, D.Sc., Ph.D.
Senior Research Officer—I. Brown, B.Sc.
Senior Research Officer—V. Garten, D.Sc.
Senior Research Officer—M. E. Winfield, M.Sc., Ph.D.
Research Officer—J. A. Barker, B.A., B.Sc.
Research Officer—J. Bowler Reed, B.Sc., Ph.D.
Research Officer—H. G. David, B.Sc. (at Department of Chemical Engineering, University of Sydney).
Research Officer—A. Ewald, B.Sc., Ph.D. (on study leave).
Research Officer—W. E. Ewers, M.Sc.
Research Officer—S. D. Hamann, M.Sc., Ph.D. (at Department of Chemical Engineering, University of Sydney).
Research Officer—W. W. Mansfield, B.Sc.
Research Officer—E. A. Swinton, B.Sc.
Research Officer—D. E. Weiss, B.Sc.
Senior Technical Officer—L. F. Evans, D.S.M.B.
Technical Officer—W. Fock, B.Sc.
Technical Officer—J. A. Lambert, B.Sc. (at Department of Chemical Engineering, University of Sydney).
Technical Officer—M. Linton, B.Sc.
Technical Officer—R. McNeill, A.S.T.C.
Technical Officer—F. Meadows, B.Sc.
Technical Officer—M. Ross, Ing.
Technical Officer—F. Smith, B.Sc.
Technical Officer—G. K. Sutherland, B.Sc.

anic Chemistry Section—

Senior Principal Research Officer—H. H. Hatt, D.Sc., Ph.D.
Principal Research Officer—J. R. Price, M.Sc., D.Phil.
Principal Research Officer—W. Zimmermann, D.Ing.
Senior Research Officer—R. G. Curtis, M.Sc., D.I.C.
Senior Research Officer—J. S. Fitzgerald, M.Sc., Ph.D.
Senior Research Officer—K. E. Murray, B.Sc.
Research Officer—C. S. Barnes, M.Sc. (on study leave).
Research Officer—R. B. Bradbury, B.Sc.Agr., D.B.S.M.
Research Officer—W. D. Crow, M.Sc., Ph.D.
Research Officer—C. C. J. Culvenor, Ph.D., D.Phil.
Research Officer—L. K. Dalton, A.S.T.C.
Research Officer—H. Duewell, B.Sc., Ph.D.
Research Officer—E. Gellert, Ph.D.
Research Officer—N. C. Hancox, M.Sc.
Research Officer—J. A. Lamberton, B.Sc., Ph.D.
Research Officer—R. J. L. Martin, M.Sc., Ph.D.
Technical Officer—P. M. Hunter, A.S.T.C.
Technical Officer—Miss M. D. Keith, A.M.T.C.
Technical Officer—M. Michael, M.Sc.
Technical Officer—A. H. Redcliffe, Dip.Anal. Chem. M.U.

Technical Officer—Miss E. E. Rutherford, B.Sc.
Technical Officer—R. Schoenfeld, B.Sc.
Technical Officer—L. W. Smith, B.Sc.
Technical Officer—A. Z. Szumer.

Chemical Engineering Section—

Senior Research Officer—R. W. Urie, B.Sc., S.M.
Research Officer—F. H. Barr-David, B.Sc.
Research Officer—T. J. Birch, B.Sc.
Research Officer—K. R. Hall, B.Sc. (on study leave).
Research Officer—O. G. Ingles, M.Sc.
Research Officer—A. R. King, B.Sc.
Research Officer—D. F. A. Koch, B.Sc.
Research Officer—P. Terry, B.Sc. (on study leave).
Research Officer—A. B. Whitehead, B.Sc.
Senior Technical Officer—J. B. Ross, B.Sc., A.M.T.C.
Senior Technical Officer—D. H. Trethewey, A.M.T.C.
Senior Technical Officer—B. W. Wilson, M.Sc.
Technical Officer—P. Casamento, D.Ing.
Technical Officer—K. W. Foley, B.Sc. (on study leave).
Technical Officer—C. G. MacFarlane, B.Sc.
Technical Officer—C. W. Thomas, B.Sc.
Sectional Draughtsman—C. Simpson.

At Division of Plant Industry, Canberra—

Research Officer—W. Bottomley, M.Sc. (seconded) (on study leave).

At Division of Electrotechnology, Sydney—

Research Officer—H. K. Welsh, B.Sc. (seconded).

Photography—

Technical Officer—F. D. Lugton.

Library—

Librarian—Miss B. M. Brown, B.Sc.

18. IRRIGATION RESEARCH STATION (MURRUMBIDGEE IRRIGATION AREAS).

(Head-quarters: Griffith, New South Wales.)

Officer-in-charge—E. S. West, B.Sc., M.S.
Senior Research Officer—R. F. Williams, M.Sc.
Research Officer—O. Perkman, B.Sc.Agr.
Research Officer—C. T. Gates, B.Sc.Agr.
Senior Technical Officer—B. H. Martin, H.D.A.
Librarian—Miss M. Russell.

Seconded to New South Wales Department of Agriculture—

Senior Research Officer—D. V. Walters, M.Agr.Sc.
Research Officer—Mrs. J. Tully, B.Sc., Ph.D.

19. LAND RESEARCH AND REGIONAL SURVEY SECTION.

(Head-quarters: Canberra, Australian Capital Territory.)

At Head-quarters, Canberra—

Officer-in-charge—C. S. Christian, B.Sc.Agr., M.S.
Technical Secretary—Miss M. Mills, B.Sc.
Principal Research Officer—E. Phillis, Ph.D., D.Sc.
Research Officer—R. O. Slatyer, B.Sc.(Agric.).

At Kimberley Research Station, Western Australia—

Research Officer—L. C. Lee, B.Agr.Sc.
Technical Officer—E. C. B. Langfield.
Technical Officer—P. J. Cheetham, Q.D.H.

At Katherine Research Station, Northern Territory—

Research Officer—W. Arndt, B.Sc.Agr.
Research Officer—F. H. Kleinschmidt, B.Sc.Agr.
Technical Officer—L. J. Phillips, Q.D.D.M.
Technical Officer—W. R. Stern, B.Sc.Agr.
Technical Officer—W. Stahl.

Regional Survey, Canberra—

Senior Research Officer—G. A. Stewart, B.Agr.Sc.
Research Officer—R. A. Perry, B.Sc.
Research Officer—J. Sleeman, B.Agr.Sc. (seconded from Division of Soils).
Research Officer—C. R. Twidale, M.Sc.
Technical Officer—M. Lazarides, Q.D.A.

Papua-New Guinea Resources Survey, Canberra—

Research Officer—S. J. Paterson, B.Sc.
Research Officer—H. A. Haantjens, Ing.Agr. (seconded from Division of Soils).
Research Officer—R. D. Hoogland, D.Sc.
Research Officer—B. W. Taylor, B.Sc.

20. Section of Mathematical Instruments.

(Head-quarters: University of Sydney.)

Officer-in-charge—Professor D. M. Myers, B.Sc., D.Sc.Eng.
Research Officer—M. W. Allen, B.E.
Technical Officer—R. J. Keith, B.E., A.S.T.C.

21. Section of Mathematical Statistics.

(Head-quarters: University of Adelaide.)

At Head-quarters, Adelaide—

Officer-in-charge—E. A. Cornish, D.Sc., B.Agr.Sc.
Research Officer—Mrs. E. Bofinger, B.Sc.
Research Officer—V. J. Bofinger, B.Sc.
Research Officer—A. G. L. Elliott, B.Sc.
Research Officer—K. P. Haydock, B.Sc.
Research Officer—A. T. James, M.Sc. (abroad).
Research Officer—P. F. May, B.Sc.Agr.
Research Officer—G. N. Wilkinson, B.Sc.
Technical Officer—M. L. Dudzinski, B.Sc.
Sectional Secretary—Miss E. M. G. Goodale.

At Division of Animal Health and Production, Sydney—

Senior Research Officer—Miss H. A. Newton Turner, B.Arch.
Research Officer—H. A. David, B.Sc., Ph.D.
Research Officer—Miss M. C. McKevett, B.A.

At Division of Building Research, Highett, Victoria—

Research Officer—R. Birtwistle, B.Sc.
Research Officer—W. B. Hall, B.A.

At Division of Food Preservation and Transport, Homebush, New South Wales—

Research Officer—G. G. Coote, B.A., B.Sc.

At Division of Forest Products, Melbourne—

Senior Research Officer—E. J. Williams, B.Com.
Technical Officer—Miss N. Ditchburne.

At Division of Plant Industry, Canberra—

Principal Research Officer—G. A. McIntyre, B.Sc., Dip.Ed.
Research Officer—Miss N. B. Hemingway, B.Sc.

At University of Western Australia, Perth—

Research Officer—N. S. Stenhouse, B.Sc.

22. Section of Meteorological Physics.

(Head-quarters: Graham-road, Highett, Victoria.)

Officer-in-charge—C. H. B. Priestley, M.A., Sc.D.
Principal Research Officer—W. C. Swinbank, B.Sc.
Principal Research Officer—E. L. Deacon, B.Sc.
Principal Research Officer—F. A. Berson, Ph.D.
Research Officer—I. C. McIlroy, B.Sc.
Research Officer—R. J. Taylor, B.Sc.
Research Officer—E. K. Webb, B.A., B.Sc.
Research Officer—F. K. Ball, B.Sc.
Research Officer—C. F. Barrett, M.Sc.
Research Officer—W. W. Moriarty, M.Sc.
Technical Officer—I. S. Groodin, Dip.Mat.
Technical Officer—D. E. Angus, B.Sc.
Technical Officer—A. J. Troup, B.Sc.
Technical Officer—D. R. Samuel, Dip.App.Sc.

23. Division of Metrology.

(Head-quarters: National Standards Laboratory at University of Sydney.)

Chief—N. A. Esserman, B.Sc.
Technical Secretary—N. H. Winters, B.E.
Principal Research Officer—C. A. Gladman, B.Sc.(Eng.), A.C.G.I.
Principal Research Officer—G. A. Bell, B.Sc.
Senior Research Officer—C. F. Bruce, M.Sc.
Senior Research Officer—H. J. Ritter, Dr.rer.nat.-math.
Senior Research Officer—H. A. Ross, A.S.T.C.
Research Officer—R. H. Furniss, A.S.T.C.
Research Officer—J. A. Macinante, B.E., A.S.T.C.
Research Officer—M. J. Puttock, B.Sc.(Eng.)
Research Officer—W. A. F. Cuninghame, B.E.
Research Officer—Miss M. C. Dive, B.Sc.
Research Officer—Miss M. G. I. Pearce, M.Sc.
Research Officer—Miss P. M. Yelland.
Research Officer—R. J. Ellis, B.E.
Research Officer—Miss M. M. Douglas, B.Sc.
Research Officer—J. Waldersee, B.Sc.
Research Officer—N. J. C. Peres, M.Sc.
Research Officer—B. S. Thornton, M.Sc.
Research Officer—J. Rector, B.Sc., B.E.
Research Officer—I. F. Mayer, B.Sc., B.E.
Senior Technical Officer—R. Springer.
Technical Officer—D. H. Fox.
Technical Officer—G. W. Gore, A.S.T.C.
Technical Officer—J. W. Bell.
Technical Officer—E. Grunwald.
Technical Officer—J. C. Kelley, B.Sc.
Technical Officer—E. J. Thwaite, B.Sc.
Technical Officer—I. J. Somervaille, B.E., A.S.T.C.
Technical Officer—S. A. Dunk, B.E., A.S.T.C.
Technical Officer—P. Albrecht, Dipl.Ing.
Technical Officer—O. Pain.

24. Mineragraphic Investigations.

(Head-quarters: University of Melbourne.)

Senior Principal Research Officer—F. L. Stillwell, D.Sc.
Senior Principal Research Officer—A. B. Edwards, D.Sc., Ph.D.
Research Officer—G. Baker, M.Sc.
Research Officer—J. McAndrew, B.Sc., Ph.D.
Technical Officer—G. C. Carlos.

25. National Standards Laboratory.

(The services shown hereunder are common to the Divisions of Metrology, Electrotechnology, and Physics, housed in the Laboratory.)

Clerical—

Chief Clerk—W. J. Gillespie, F.A.S.A., A.C.I.S., J.P.
Accountant—F. J. Whitty.

Library—

Librarian—Miss M. McKechnie, B.A.
Librarian—Miss J. M. Cook, B.A.
Librarian—Miss C. Gough.

Workshops—

Engineer-in-charge—J. Hanna.

Drawing Office—

Sectional Draughtsman—B. H. P. Cresswell, Dip.Mech.Eng.
Sectional Draughtsman—J. Coles.
Draughtsman, Grade II.—R. Riches.
Draughtsman, Grade II.—R. Partridge.
Draughtsman, Grade II.—J. Weir.
Draughtsman, Grade II.—K. Apps, Dip.Mech.Eng.

26. Oenological Research.

(Head-quarters: Waite Agricultural Research Institute, Adelaide.)

Senior Research Officer—J. C. M. Fornachon, M.Sc., B.Ag.Sc.
Research Officer—B. C. Rankine, M.Sc.

27. Ore-dressing Investigations.

At University of Melbourne—
Officer-in-charge—Associate Professor H. H. Dunkin, B.Met.E.
Principal Research Officer—K. S. Blaskett, B.E.
Research Officer—S. B. Hudson, M.Sc.
Research Officer—J. T. Woodcock, B.Met.E., M.Eng.Sc.
Senior Technical Officer—F. D. Drews.
Technical Officer—R. R. Lever.
Technical Officer—T. F. Wallace.

28. Section of Physical Metallurgy.

(Head-quarters: University of Melbourne.)

Officer-in-charge (honorary)—Professor J. Neill Greenwood, D.Sc., M.Met.E.
Senior Research Officer—H. W. Worner, M.Sc.
Senior Research Officer—R. C. Gifkins, B.Sc.
Research Officer—A. E. Jenkins, M.Eng.Sc.
Technical Officer—J. A. Corbett.
Technical Officer—G. N. Goyd, A.M.T.C.

29. Division of Physics.

(Head-quarters: National Standards Laboratory at University of Sydney.)

Administration—
Chief—G. H. Briggs, D.Sc., Ph.D.
Technical Secretary—D. S. Woodward.

Heat—
Principal Research Officer—A. F. A. Harper, M.Sc.
Research Officer—W. R. G. Kemp, B.Sc.
Research Office—R. G. Wylie, M.Sc., Ph.D.
Research Officer—G. K. White, M.Sc., D.Phil.
Research Officer—P. G. Klemens, M.Sc., D.Phil.
Research Officer—W. A. Caw, B.Sc.
Research Officer—Miss R. Scott, B.Sc.
Research Officer—N. H. Westwood, B.Sc.
Research Officer—A. J. Mortlock, M.Sc.
Research Officer—J. Middlehurst, B.Sc.
Technical Officer—J. V. McAllan, B.Sc.
Technical Officer—Miss I. M. Beavis, B.Sc., Dip.Ed.
Technical Officer—J. K. Braithwaite, A.M.T.C.
Technical Officer—J. W. W. Smyth.

Light—
Principal Research Officer—R. G. Giovanelli, D.Sc.
Research Officer—W. H. Steel, B.A., B.Sc., Dr. ès Sc.
Research Officer—K. A. Wright, B.Sc.
Research Officer—W. R. Blevin, B.Sc., Dip.Ed.
Research Officer—Associate Professor G. H. Godfrey, M.A., B.Sc. (part-time).
Technical Officer—W. J. Brown, A.S.T.C.
Technical Officer—D. G. Norton.
Technical Officer—Miss J. Ward.

Solar Physics—
Research Officer—J. T. Jefferies, M.A., B.Sc.
Research Officer—R. J. LeMesurier, B.Sc.
Technical Officer—V. R. Burgess, A.S.T.C.

Electronics—
Research Officer—A. F. Young, M.Sc.

30. Plant Fibre Section.

(Head-quarters: Graham-road, Highett, Victoria.)

Officer-in-charge—W. L. Greenhill, M.E.
Senior Research Officer—Miss J. F. Couchman, B.Sc.
Senior Research Officer—G. W. Lanigan, M.Sc.
Research Officer—W. Shepherd, B.Sc., B.Ag.Sc.
Technical Officer—C. J. Brady, B.Ag.Sc.
Technical Officer—M. Tisdall, A.M.T.C.

31. Division of Plant Industry.

(Head-quarters: Canberra, Australian Capital Territory.)

Chief—O. H. Frankel, D.Sc., D.Agr., F.R.S.
Technical Secretary—A. Shavitsky, B.Agr.Sc.

General Services, Canberra—
Librarian—Miss J. Humphreys, B.A., Dip.Ed. (half-time).
Technical Officer—J. Deans.
Technical Officer—R. Rochford.
Technical Officer—J. Pomeroy.
Technical Officer—C. Wilson.
Chief Clerk—K. J. Prowse (half-time).
Deputy Chief Clerk—D. Banyard (half-time).
Accountant—L. G. Peres, B.Ec. (half-time).

Group 1.—Botany and Genetics—
Leader—O. H. Frankel, D.Sc., D.Agr., F.R.S.
Deputy Leader—C. Barnard, D.Sc.
Senior Research Fellow—M. J. D. White, D.Sc.
Senior Research Fellow—K. O. Muller, D.Phil.
Senior Research Fellow—P. S. Nutman, B.Sc., Ph.D.

Genetics and Cytology, Canberra—
Principal Research Officer—E. M. Hutton, D.Sc., B.Agr.Sc.
Research Officer—R. D. Brock, B.Agr.Sc. (studentship abroad).
Technical Officer—Mrs. D. Foster, B.Sc.
Technical Officer—A. R. Peak, H.D.A.
Technical Officer—J. W. Peak.

Structural Botany, Canberra—
Principal Research Officer—C. Barnard, D.Sc.

Plant Introduction, Canberra—
Principal Research Officer—W. Hartley, B.A., Dip.Agr.
Research Officer—C. A. Neal-Smith, B.Agr.Sc., R.D.A.
Technical Officer—R. J. Williams, B.Sc.
Technical Officer—Miss D. E. Johns, B.Sc.
Technical Officer—R. Seton.

Herbarium, Canberra—
Research Officer—Miss N. T. Burbidge, M.Sc. (abroad).

Plant Introduction, Queensland—
Senior Research Officer—J. F. Miles, B.Agr.Sc.
Research Officer—E. H. Kipps, B.Sc.
Technical Officer—R. B. Waite, Q.D.A.

Plant Introduction, Katherine, Northern Territory—
Technical Officer—A. E. Wynn.

Plant Introduction, Armidale, New South Wales—
Technical Officer—L. Sharp, D.D.A.

Plant Introduction, Western Australia—
Senior Research Officer—E. T. Bailey, B.Sc.
Technical Officer—N. B. Gayfer, Dip.Agr.D.
Technical Officer—A. L. Rogers.

Microbiology, Canberra—
Principal Research Officer—D. O. Norris, D.Sc. (Agric.)
Research Officer—J. H. E. Mackay, B.Sc.Agr.
Research Officer—Miss K. Helms, B.Sc. (studentship abroad).

Technical Officer—J. Brockwell, D.D.A.
Technical Officer—Miss J. Friend, B.Sc.Agr.

Soil Microbiology, Canberra—

Research Officer—F. W. Hely, M.Sc.Agr., M.S.
Research Officer—S. M. Bromfield, M.Agr.Sc., Ph.D.

Disease Control Investigations, Canberra—

Principal Research Officer—H. R. Angell, O.B.E., Ph.D.
Technical Officer—C. S. McKay, D.D.A.

Fruit Investigations, Hobart—

Principal Research Officer—D. Martin, M.Sc.
Research Officer—T. L. Lewis, B.Sc.
Technical Officer—J. Cerny, Ph.D.

Fruit Investigations, Applethorpe, Queensland—

Principal Research Officer—L. A. Thomas, M.Sc.
Research Officer—R. C. Colbran, B.Agr.Sc.

Tobacco, Canberra—

Principal Research Officer—A. V. Hill, M.Agr.Sc.
Research Officer—D. C. Wark, M.Agr.Sc.
Technical Officer—M. Mandryk, B.Sc.Agr.

Group 2.—Chemistry and Physiology—

General Chemistry, Canberra—

Senior Research Officer—C. H. Williams, M.Sc.
Research Officer—A. Steinbergs, Nut.Chem.Univ.
Research Officer—D. J. David, B.Sc. (at Adelaide).
Technical Officer—K. Mayer, Q.D.A.

Soil Chemistry, Melbourne—

Research Officer—L. H. P. Jones, Ph.D., B.Agr.Sc.

Plant Nutrition, Canberra—

Principal Research Officer—A. J. Anderson, B.Sc. (Agric.).
Research Officer—K. D. MacLachlan, B.Sc.Agr., B.Comm.
Research Officer—D. Spencer, B.Sc., Ph.D.
Research Officer—J. V. Possingham, B.Agr.Sc.
Technical Officer—D. R. Meyer.
Technical Officer—R. G. Fawcett, R.D.A.

Plant Toxicology, Canberra—

Principal Research Officer—C. G. Greenham, M.Sc.
Technical Officer—C. V. de Plater, A.I.M.R.E.

Plant Biochemistry, Canberra—

Research Officer—P. L. Goldacre, M.Sc., Ph.D.
Research Officer—W. Bottomley, B.Sc., Ph.D. (scholarship abroad).
Technical Officer—P. I. Mortimer, B.Sc.

Plant Biochemistry, at University of Melbourne—

Research Officer—C. A. Appleby, B.Sc.

Tobacco Biochemistry, Canberra—

Research Officer—R. J. Johanson, M.Sc.
Technical Officer—I. F. Reynolds, B.Sc.

Plant Physiology, Canberra—

Principal Research Officer—L. A. T. Ballard, Ph.D., M.A., M.Ag.Sc.
Research Officer—A. H. J. Rijven, Ph.D., M.Sc.
Research Officer—J. F. Loneragan, B.Agr.Sc. (studentship abroad).
Research Officer—N. P. Kefford, M.Sc. (studentship abroad).
Research Officer—J. Zwar, M.Agr.Sc.

Tobacco Physiology, Canberra—

Research Officer—J. Calvert, D.Sc.

Group 3.—Agrostology and Agronomy—(Southern and Western Australia)—

Leader—C. M. Donald, M.Sc.Agr.

At Canberra—

Agrostology and Agronomy—

Senior Principal Research Officer—C. M. Donald, M.Sc.Agr.
Technical Officer—J. D. Williams, D.D.A.

Dickson Experiment Station—

Senior Research Officer—W. D. Andrew, M.Agr.Sc.
Research Officer—W. M. Willoughby, B.Sc.Agr.
Technical Officer—J. A. Redpath.
Technical Officer—R. T. Milligan, D.D.A.
Technical Officer—V. H. Southwell.
Technical Officer—A. Axelsen, Q.D.A.H.

Ecology—

Principal Research Officer—R. M. Moore, M.Sc.Agr.
Research Officer—C. W. E. Moore, B.Agr.Sc.
Research Officer—L. F. Myers, B.Agr.Sc.
Research Officer—E. F. Biddiscombe, B.Sc. (Agric.).
Technical Officer—J. A. Robertson, Q.D.D.M.
Technical Officer—J. A. Bull.

At Institute of Agriculture, Perth—

Senior Research Officer—R. C. Rossiter, D.Sc., B.Sc.(Agric.).
Research Officer—P. G. Ozanne, B.Sc.(Agric.).
Research Officer—A. W. Humphries, B.Sc. (Agric.).
Technical Officer—R. J. Pack, Q.D.A.
Technical Officer—T. Shaw, B.Sc.
Technical Officer—D. J. Kirton, B.Sc.(Agric.).

At Glen Lossie Field Station, Kojonup, Western Australia—

Research Officer—E. Watson, B.Sc.(Agric.).
Senior Technical Officer—J. Tudor.
Technical Officer—P. Lapins.
Technical Officer—J. Beresford, D.D.A.

At Regional Pastoral Laboratory, Armidale, New South Wales—

Agrostology and Agronomy—

Senior Research Officer—R. Roe, B.Sc.(Agric.).
Research Officer—K. Spencer, B.Sc.Agr.
Research Officer—E. J. Hilder, B.Sc.(Agric.).
Research Officer—J. E. Begg, B.Sc.Agr.
Technical Officer—J. R. Freney, B.Sc.
Technical Officer—V. J. Wolfe, Q.D.A.
Technical Officer—Miss J. A. Stubbs, B.Sc.Agr.
Technical Officer—B. E. Mottershead, B.Sc.

Ecology—

Research Officer—R. W. Jessup, M.Sc.
Research Officer—A. A. Holland, M.Sc.
Technical Officer—F. R. Gnauck, B.Sc.

At Mitchell Laboratory, Trangie, New South Wales—

Technical Officer—R. J. Hutchings, D.D.A.

At Regional Laboratory, Deniliquin, New South Wales—

Principal Research Officer—R. W. Prunster, B.Sc.(Agric.).
Research Officer—J. R. Philip, B.C.E.
Research Officer—O. B. Williams, B.Agr.Sc.
Research Officer—K. P. J. Barley, B.Agr.Sc. (scholarship abroad).
Research Officer—J. N. R. Bickerdike, B.A.
Technical Officer—J. W. Birch, D.D.A.
Technical Officer—G. J. Wright, D.D.A.
Technical Officer—F. Arndt, Q.D.A.

At Falkiner Memorial Field Station, Deniliquin, New South Wales—

Technical Officer—G. A. Vasey, D.D.A.

At Irrigation Research Station, Griffith, New South Wales—

Ecology—

Research Officer—E. Levi, M.Sc.

Waite Institute, Adelaide, South Australia—

Oil Crop Investigations—

Senior Research Officer—B. Horowitz, D.Agr.

University of Queensland, Brisbane—

Ecology—

Research Officer—L. J. Webb, M.Sc.
Technical Officer—J. G. Tracey, Q.D.A.

roup 4.—Agrostology and Agronomy (Queensland)—

Leader—J. Griffiths Davies, B.Sc., Ph.D.

Plant and Soils Regional Laboratory, Brisbane—

Associate Chief—J. Griffiths Davies, B.Sc., Ph.D.
Principal Research Officer—T. B. Paltridge, B.Sc.

Agronomy—

Senior Research Officer—W. W. Bryan, M.Sc.Agr.
Research Officer—S. G. Gray, B.Sc.Agr.
Technical Officer—B. B. Brett, B.Agr.Sc., Q.D.A.
Technical Officer—J. J. F. Conroy, Q.D.A.

Cattle Pastures—

Senior Research Officer—N. H. Shaw, B.Sc.Agr.
Technical Officer—T. W. Blich, Dip.Col.Agr.

Plant Introduction—

Senior Research Officer—J. F. Miles, M.Sc.Agr.
Research Officer—E. H. Kipps, B.Sc.
Technical Officer—R. B. Waite, Q.D.A.

Plant Nutrition—

Research Officer—C. S. Andrew, B.Ag.Sc.
Technical Officer—W. H. J. Pieters, Dip.Col.Agr.

Plant Chemistry—

Research Officer—M. P. Hegarty, M.Sc.

Ecology—

Research Officer—J. E. Coaldrake, B.Sc.
Technical Officer—W. F. Ridley, B.Sc.

t Cooper Laboratory, Lawes, Queensland—

Research Officer—W. J. Bisset, B.Agr.Sc.
Technical Officer—R. Milford, B.Agr.Sc.
Technical Officer—G. A. Taylor, Q.D.A.
Technical Officer—H. J. Kiers, Dip.Col.Agr.
Technical Officer—A. M. Sanders, Dip.Col.Agr.

t Ayr, Queensland—

Tobacco—

Research Officer—W. J. Lovett, B.Agr.Sc.
Technical Officer—J. D. Fitzsimon, Q.D.H.
Technical Officer—J. B. Murday, Q.D.A.

32. DIVISION OF RADIOPHYSICS.

(Head-quarters: University of Sydney.)

hief—E. G. Bowen, O.B.E., M.Sc., Ph.D.
ssistant Chief—J. L. Pawsey, M.Sc., Ph.D.
echnical Secretary—A. J. Higgs, B.Sc. (abroad).
cting Technical Secretary—L. L. McCready, B.Sc., B.E.

loud and Rain Physics—

Senior Research Officer—J. Warner, B.Sc., B.E.
Senior Research Officer—P. Squires, M.A.
Senior Research Officer—E. J. Smith, M.B.E., B.Sc.(Eng.).
Research Officer—N. R. Labrum, B.Sc.
Research Officer—E. E. Adderley, B.Sc.
Research Officer—S. Twomey, M.Sc.
Research Officer—J. W. Telford, B.Sc.
Research Officer—J. S. Turner, M.Sc.
Technical Officer—T. D. Newnham.
Technical Officer—L. F. Clague.
Technical Officer—K. J. Heffernan.
Technical Officer—K. A. Davidson.
Technical Officer—D. C. Dunn.
Technical Officer—N. S. Thorndike.
Technical Officer—R. T. H. Bowles, A.M.T.C.

Radio Astronomy—

Principal Research Officer—J. H. Piddington, M.Sc., B.E., Ph.D.
Senior Research Officer—W. N. Christiansen, M.Sc.
Senior Research Officer—J. G. Bolton, B.A.
Senior Research Officer—F. J. Kerr, M.Sc., M.A.
Senior Research Officer—B. Y. Mills, B.Sc., M.E.
Research Officer—R. N. Bracewell, B.Sc., B.E., Ph.D.
Research Officer—J. P. Wild, M.A.
Research Officer—S. F. Smerd, B.Sc.
Research Officer—C. A. Shain, B.Sc.
Research Officer—J. A. Roberts, M.Sc., Ph.D.
Research Officer—R. X. McGee, B.Sc.
Research Officer—R. D. Davies, M.Sc.
Research Officer—J. A. Warburton, B.Sc.
Research Officer—B. J. Robinson, M.Sc.
Research Officer—A. W. L. Carter, B.Sc.
Senior Technical Officer—K. V. Sheridan, B.Sc.
Senior Technical Officer—J. V. Hindman.
Technical Officer—G. J. Stanley, A.S.T.C.
Technical Officer—C. S. Higgins.
Technical Officer—J. D. Murray, B.Sc.(Eng.).
Technical Officer—A. G. Little, A.S.T.C.
Technical Officer—O. B. Slee, A.S.T.C.
Technical Officer—H. R. Harant, A.S.T.C.

Transistor Physics—

Senior Research Officer—B. F. C. Cooper, B.Sc., B.E.
Research Officer—L. W. Davies, B.Sc., D.Phil.
Research Officer—D. Haneman, M.Sc.
Technical Officer—F. C. James.
Technical Officer—S. A. Pett.

Radio Navigational Aids—

Senior Research Officer—H. C. Minnett, B.Sc., B.E.
Research Officer—G. A. Day.
Research Officer—D. E. Yabsley, B.Sc., B.E.
Research Officer—F. F. Gardner, B.Sc., B.E.
Senior Technical Officer—G. T. Miles.
Senior Technical Officer—P. T. Hedges, A.S.T.C.
Technical Officer—R. S. Joseph, A.S.T.C.
Technical Officer—C. F. Attwood.

Mathematical Computation—

Senior Research Officer—T. Pearcey, B.Sc.
Senior Research Officer—M. Beard, B.Sc., B.E.
Research Officer—Miss M. A. Adamson, B.A., Dip.Ed.
Research Officer—R. D. Ryan, B.Sc., B.E.
Research Officer—G. W. Hill, B.Sc.
Research Officer—B. J. J. McHugh, B.Sc.
Senior Technical Officer—F. C. Tonking, A.S.T.C.
Technical Officer—J. E. Algie, A.S.T.C.
Technical Officer—R. C. Baker.

Test Room—

Senior Technical Officer—G. A. Wells, A.S.T.C.
Technical Officer—T. E. Cousins, A.S.T.C.

Engineering Services—

Chief Draughtsman—F. M. Carter.
Senior Technical Officer—H. Byers.
Draughtsman, Grade II.—H. F. Peddie, A.S.T.C.
Draughtsman, Grade II.—J. R. Morris.
Draughtsman, Grade II.—D. E. Brown, A.S.T.C.
Senior Technical Officer—K. A. McAlister, A.S.T.C.
Technical Officer—O. C. Turner.

Officers Abroad—

Research Officer—E. K. Bigg, M.Sc.
Research Officer—E. R. Hill, M.Sc.
Research Officer—R. F. Mullaly, B.Sc.

33. Radio Research Board.

(Head-quarters: University of Sydney.)

At Canberra—

Chief Scientific Officer—D. F. Martyn, D.Sc., Ph.D., A.R.C.S., F.R.S.

At Sydney—

Principal Research Officer—G. H. Munro, D.Sc.
Senior Research Officer—W. L. Price, B.Sc. (part-time).
Research Officer—J. A. Harvey, B.Sc.
Research Officer—L. Heisler, B.Sc.
Technical Officer—Miss B. Hardwick, B.A.
Technical Officer—H. P. Hirschl, A.S.T.C.
Technical Officer—R. B. White, B.E.

34. Division of Soils.

(Head-quarters: Waite Agricultural Research Institute, Adelaide.)

At Adelaide—

Administration—

Chief—J. K. Taylor, B.A., M.Sc., B.Sc.Agr.
Technical Secretary—A. L. C. Davidson, B.Sc., Ph.D.

Soil Survey and Pedology Section—

Senior Principal Research Officer—C. G. Stephens, D.Sc.
Research Officer—K. H. Northcote, B.Ag.Sc.
Research Officer—G. Blackburn, B.Ag.Sc.
Research Officer—E. A. Jackson, B.Ag.Sc.
Research Officer—C. B. Wells, B.Ag.Sc.
Research Officer—W. H. Litchfield, B.Sc.Agr.
Research Officer—M. J. Mulcahy, B.Sc.
Research Officer—Ir. T. Talsma.
Cartographer—P. D. Hooper.

Soil Chemistry Section—

Principal Chemist—C. S. Piper, D.Sc. (abroad).
Senior Research Officer—A. C. Oertel, M.Sc (abroad).
Senior Research Officer—R. E. Shapter, A.A.C.I.
Research Officer—J. T. Hutton, B.Sc., A.S.A.S.M.
Research Officer—H. C. T. Stace, B.Sc.
Research Officer—B. M. Tucker, B.Sc.
Research Officer—R. S. Beckwith, B.Sc.
Research Officer—M. Raupach, B.Sc.
Technical Officer—A. D. Haldane, B.Sc.
Technical Officer—A. R. P. Clarke, A.S.A.S.M.
Technical Officer—R. M. McKenzie, A.S.A.S.M.
Technical Officer—R. D. Bond, A.S.A.S.M.

Soil Physics and Mechanics Section—

Senior Principal Research Officer—T. J. Marshall, M.Ag.Sc., Ph.D.
Senior Research Officer—G. D. Aitchison, M.E. (at University of Melbourne).
Research Officer—K. Norrish, M.Sc., Ph.D.
Research Officer—J. P. Quirk, B.Sc.Agr., Ph.D.
Research Officer—C. G. Gurr, B.Sc.
Research Officer—J. W. Holmes, B.Sc.
Research Officer—E. W. Radoslovich, M.Sc. (abroad).
Research Officer—D. S. McIntyre, M.Sc.
Technical Officer—Mrs. L. E. R. Rogers, M.Sc.
Technical Officer—A. W. Palm.

Soil Microbiology Section—

Principal Research Officer—R. J. Swaby, M.Sc., M.Ag.Sc., Ph.D.
Research Officer—J. R. Harris, M.Sc.
Technical Officer—Mrs. B. I. Passey, B.Sc.

At Brisbane—

Soil Survey and Pedology—

Senior Research Officer—G. D. Hubble, B.Ag.Sc.
Research Officer—G. G. Beckmann, B.Sc.
Technical Officer—C. H. Thompson, Q.D.A.

Soil Physics—

Research Officer—G. B. Stirk, B.Sc.
Technical Officer—A. V. Blackmore, B.Sc.

Soil Chemistry—

Research Officer—A. E. Martin, B.Sc., F.R.I.C.
Research Officer—J. E. Cox, B.Sc.
Technical Officer—R. Reeve, Dip.Ind.Chem.
Technical Officer—H. J. Beatty, Dip.Ind.Chem.

At Canberra—

Soil Survey and Pedology—

Research Officer—R. Brewer, B.Sc.
Research Officer—D. C. van Dijk, l.i., Dr.rer.nat.
Research Officer—J. R. Sleeman, B.Ag.Sc. (seconded to Land Research and Regional Survey Section).

At Deniliquin—

Soil Survey and Pedology—

Senior Research Officer—B. E. Butler, B.Agr.Sc.
Research Officer—H. M. Churchward, B.Sc.Agr.

At Hobart—

Soil Survey and Pedology—

Research Officer—K. D. Nicolls, B.Ag.Sc., B.Sc.
Research Officer—G. M. Dimmock, B.Sc.
Research Officer—J. Loveday, B.Ag.Sc.

Soil Chemistry—

Technical Officer—A. M. Graley, B.Sc.

At Perth—

Soil Survey and Pedology—

Senior Research Officer—R. Smith, D.Sc.(Agr.) (abroad).
Research Officer—L. W. Pym, B.Sc.(Agr.)
Research Officer—T. Poutsma, B.Sc.(Agr.)
Research Officer—W. M. McArthur, B.Sc.
Technical Officer—E. Bettenay, B.Sc.(Agr.).

Soil Chemistry—

Research Officer—A. G. Turton, B.Sc.
Technical Officer—F. J. Hingston, B.Sc.

35. Division of Tribophysics.

(Head-quarters: University of Melbourne.)

Chief—W. Boas, D.Ing., M.Sc.
Senior Research Officer—M. F. R. Mulcahy, D.Phil., M.Sc., A.G.Inst.Tech.
Senior Research Officer—J. K. Mackenzie, Ph.D., B.A., B.Sc.
Senior Research Officer—A. J. W. Moore, Ph.D., B.Sc.
Research Officer—J. S. Bowles, M.Sc.
Research Officer—L. M. Clarebrough, B.Met.E., M.Eng.Sc.
Research Officer—B. D. Cuming, M.Sc. (abroad).
Research Officer—A. J. Davis, B.Eng.
Research Officer—M. E. Hargreaves, Ph.D., B.Met.E.
Research Officer—D. Michell, B.E.E.
Research Officer—J. F. Nicholas, B.A., B.Sc. (abroad).
Research Officer—G. J. Ogilvie, Ph.D., B.Met.E., M.Eng.Sc.
Research Officer—M. J. Ridge, M.Sc. (abroad).
Research Officer—J. V. Sanders, Ph.D., B.Sc.
Research Officer—Mrs. H. M. C. Sosnowsky, Ph.D.
Research Officer—J. A. Spink, B.Sc.
Research Officer—R. G. Vines, M.Sc.
Research Officer—G. W. West, B.E.E., B.Sc.
Research Officer—J. E. Young, Ph.D., B.Sc.
Technical Officer—H. W. Hutchinson.
Technical Officer—G. Brinson, B.Sc.
Tehnical Officer—G. R. Perger, F.M.T.C.
Technical Officer—J. J. Batten, B.Sc.
Technical Officer—L. A. Bennett, B.Sc.
Technical Officer—R. W. Coventry, B.Sc.
Technical Officer—R. G. Sherwood, A.M.T.C.
Technical Officer—W. J. McG. Tegart, B.Sc., A.M.T.C.

36. Wildlife Survey Section.

(Head-quarters: Canberra, Australian Capital Territory.)

fficer-in-charge—F. N. Ratcliffe, B.A.
rincipal Research Officer—R. Carrick, B.Sc., Ph.D.
ectional Secretary—F. N. Robinson, B.A.
esearch Officer—G. M. Dunnet, B.Sc., Ph.D.
esearch Officer—J. le G. Brereton, B.Sc. (on leave abroad).
echnical Officer—R. Mykytowycz, D.V.Sc.

t *Perth*—

Senior Research Officer—D. L. Serventy, B.Sc., Ph.D.
Research Officer—W. E. Poole, B.Sc.
Technical Officer—J. H. Calaby.

t *Albury, New South Wales*—

Research Officer—B. V. Fennessy, B.Agr.Sc.
Research Officer—K. Myers, B.Sc.

t *Griffith, New South Wales*—

Research Officer—H. J. Frith, B.Sc.Agr.

t *Hobart*—

Technical Officer—I. C. R. Rowley, B.Sc.Agr.

t *Adelaide*—

Technical Officer—E. J. Waterhouse, B.Sc.Agr.

37. Wool Textile Research Laboratories.

enior Officer-in-charge—F. G. Lennox, D.Sc.

t *Wool Textile Research Laboratory, Melbourne*—

Biochemistry Unit, 343 *Royal-parade, Parkville, Victoria*—

Officer-in-charge—F. G. Lennox, D.Sc.
Laboratory Secretary—C. Garrow, B.Com., D.P.A., A.A.S.A.
Senior Research Officer—H. Lindley, B.A., Ph.D.
Senior Research Officer—W. G. Crewther, M.Sc.
Senior Research Officer—T. A. Pressley, B.Sc.
Research Officer—J. M. Gillespie, M.Sc.
Research Officer—M. A. Jermyn, M.Sc., Ph.D.
Research Officer—S. J. Leach, B.Sc.Tech., Ph.D.
Research Officer—J. M. Swan, B.Sc., Ph.D. (abroad).
Research Officer—E. F. Woods, M.Sc., A.M.T.C.
Research Officer—R. D. B. Fraser, Ph.D.
Research Officer—J. A. Friend, M.Sc., Ph.D.
Research Officer—D. H. Simmonds, M.Sc., Ph.D.
Research Officer—I. J. O'Donnell, M.Sc.
Research Officer—R. Thomas, B.Sc., Ph.D.
Research Officer—G. E. Rogers, M.Sc.
Research Officer—B. S. Harrap, Ph.D.
Research Officer—J. P. E. Human, Ph.D. (abroad).
Technical Officer—B. McQuade, B.Sc.

t *Wool Textile Research Laboratory, Sydney*—

Physics and Engineering Unit, The Hermitage, 338 *Blaxland-road, Ryde, New South Wales*—

Officer-in-charge—V. D. Burgmann, B.Sc., B.E.
Technical Secretary—I. J. W. Bisset, M.Sc.
Senior Research Officer—J. G. Downes, B.Sc.
Senior Research Officer—Mrs. K. R. Makinson, B.A.
Research Officer—M. Feughelman, B.Sc., A.S.T.C.
Research Officer—M. Chaikin, B.Sc., Ph.D., Dip. Eng.
Research Officer—I. M. Stuart, M.Sc.
Research Officer—Miss V. Laws, M.Sc.
Technical Officer—J. E. Thompson.
Technical Officer—Miss J. C. Griffith, B.Sc., A.S.T.C.
Technical Officer—A. G. Stutter, B.Sc.
Technical Officer—J. F. P. James, B.Sc.
Technical Officer—P. Nordon, A.S.T.C.
Technical Officer—B. J. Rigby, A.S.T.C.

At Wool Textile Research Laboratory, Belmont, Geelong, Victoria—

Officer-in-charge—M. Lipson, B.Sc., Ph.D.
Technical Secretary—T. Topham, A.M.I.I.A., A.T.I.
Senior Research Officer—D. L. C. Jackson, B.Sc.
Senior Research Officer—G. W. Walls, B.Sc.
Research Officer—J. Delmenico, B.Sc.
Research Officer—C. A. Anderson, B.Sc.
Research Officer—N. K. Boardman, M.Sc. (abroad).
Research Officer—J. H. Bradbury, M.Sc. (abroad).
Research Officer—D. S. Taylor, B.A., B.Sc. (abroad).
Research Officer—A. Gray, B.Sc. (abroad).
Research Officer—C. H. Nicholls, B.Sc. (abroad).
Research Officer—J. R. McPhee, B.Sc. (abroad).
Research Officer—R. F. Scrutton, M.Sc.
Research Officer—D. R. Miller, M.Sc.
Technical Officer—J. F. Sinclair.
Technical Officer—Miss R. J. Hope, A.G.Inst. Tech.
Technical Officer—G. C. West, Dipl.Text.Ind.
Technical Officer—P. Strutt, B.Sc.
Technical Officer—A. Backwell, Dipl. Text. Chem.

XXXV. PUBLISHED PAPERS.

The following papers have been published during the year:—

1. Animal Genetics Section.

Fraser, A. S. (1952).—Growth of wool fibres in sheep. *Aust. J. Agric. Res.* 3:419-34.

Fraser, A. S. (1952).—Growth of the *N*-type fleece. *Aust. J. Agric. Res.* 3:435-44.

Fraser, A. S. (1953).—Factors in genetic determination of fleece structure in sheep. *J. Genet.* 51: 222-36.

Fraser, A. S. (1953).—A note on the growth of the Res and Angora coat. *J. Genet.* 51:237-42.

Fraser, A. S., *and* Short, B. F. (1952).—Competition between skin follicles in sheep. *Aust. J. Agric. Res.* 3:445-52.

Fraser, A. S., Sobey, S., *and* Spicer, C. C. (1953).—Mottled, a sex-modified lethal in the house mouse. *J. Genet.* 51:217-21.

Hardy, M. H., Fraser, A. S., *and* Short, B. F. (1952).—Spread of pigment in sheep skin autografts. *Nature.* 170:849.

Rendel, J. M. (1952).—White heifer disease in a herd of dairy cattle. *J. Genet.* 51:89-94.

2. Division of Animal Health and Production.

Austin, C. R. (1952).—The "capacitation" of the mammalian sperm. *Nature.* 170:326.

Austin, C. R. (1952).—The development of pronuclei in the rat egg, with particular reference to quantitative relations. *Aust. J. Sci. Res.* B 5:354-65.

Austin, C. R. (1953).—Nucleic acids associated with the nucleoli of living segmented rat eggs. *Exp. Cell Res.* 4:249-51.

Austin, C. R., *and* Braden, A. W. H. (1952).—Passage of the sperm and the penetration of the egg in mammals. *Nature.* 170:919.

Austin, C. R., *and* Braden, A. W. H. (1953).—The distribution of nucleic acids in rat eggs in fertilization and early segmentation. I. Studies on living eggs by ultraviolet microscopy. *Aust. J. Biol. Sci.* 6: 324-33.

Austin, C. R., *and* Sapsford, C. S.* (1952).—The development of the rat spermatid. *J. R. Micr. Soc.* 71:397-406.

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* Faculty of Veterinary Science, University of Sydney.

Beck, A. B. (1952).—The composition of the Dwalganup strain of subterranean clover. *J. Dep. Agric. W. Aust.* 1:257-8.

Braden, A. W. H. (1952).—Properties of the membranes of rat and rabbit eggs. *Aust. J. Sci. Res.* B 5:460-71.

Braden, A. W. H., *and* Austin, C. R. (1953).—Fertilization and fertility in mammals. *Aust. Vet. J.* 29:129-32.

Bull, L. B. (1953).—Untoward effects of some pasture plants on the grazing animal. *Aust. Vet. J.* 29: 2-7.

Campbell, A. D., *and* Turner, A. W. (1953).—Studies on contagious pleuropneumonia of cattle. IV. An improved complement-fixation test for bovine pleuropneumonia. *Aust. Vet. J.* 29:154-63.

Davidson, P., *and* Hardy, M. H. (1952).—The development of mouse vibrissae *in vivo* and *in vitro*. *J. Anat. Lond.* 86:342-56.

Dick, A. T. (1952).—Improved apparatus for aspiration biopsy of the liver in sheep. *Aust. Vet. J.* 28: 234-5.

Dick, A. T. (1953).—The effect of inorganic sulphate on the excretion of molybdenum in the sheep. *Aust. Vet. J.* 29: 18-26.

Dick, A. T. (1953).—The effect of molybdenum and of lime dressings on the copper and molybdenum contents of some pasture species in the Murray Valley. *Aust. J. Agric. Res.* 4:52-6.

Dick, A. T., Moore, C. W. E., *and* Bingley, J. B. (1953).—The copper and molybdenum contents of some pasture species in the Murray Valley. *Aust. J. Agric. Res.* 4:44-51.

Durie, P. H., *and* Riek, R. F. (1952).—The role of the dingo and wallaby in the infestation of cattle with hydatids (*Echinococcus granulosis* (Barsch, 1786 Rudolphi, 1805) in Queensland. *Aust. Vet. J.* 28: 249-54.

Dwyer, F. P.*, Gyarfas, E. C.*, Rogers, W. P., *and* Koch, J. H. (1952).—Biological activity of complex ions. *Nature.* 170:190-1.

Eales, C. E., *and* Turner, A. W. (1952).—Description of *Clostridium botulinum* Type D recovered from soil in South Australia. *Aust. J. Exp. Biol. Med. Sci.* 30:295-300.

Esserman, Helene B. (1952).—The mode of action of phenothiazine as an anthelmintic. II. Phenothiazine in the intestinal fluid and nematode parasites of treated animals. *Aust. J. Sci Res.* B 5: 485-95.

Forsyth, B. A. (1953).—The experimental treatment of contagious foot-rot in sheep. *Aust. Vet. J.* 29: 73-4.

Franklin, M. C. (1952).—Beef production can be increased in Australia. *Aust. Vet. J.* 28:292-301.

Franklin, M. C. (1952).—Maintenance rations for Merino sheep. I. A comparative study of daily and weekly feeding on rations containing high proportions of wheat and several proportions of roughage to concentrate. *Aust. J. Agric. Res.* 3: 168-86.

Fraser, A. S., *and* Short, B. F. (1952).—Competition between skin follicles in sheep. *Aust. J. Agric. Res.* 3:445-52.

Gordon, H. McL. (1953).—Studies on anthelmintics for sheep: chlorinated benzenes. *Aust. Vet. J.* 29: 164-7.

Gregory, T. S. (1952).—A comparison of the effects of intracaudal and subcutaneous vaccination of calves with *Brucella abortus,* strain 19. 2. Immunity during the first pregnancy in the second year after vaccination. *Aust. Vet. J.* 28:194-200.

Gregory, T. S. (1953).—A comparison of the effects of intracaudal and subcutaneous vaccination of calves with *Brucella abortus,* strain 19. 3. Immunity in the third year after vaccination. *Aust. Vet. J.* 29: 98-103.

Gregory, T. S. (1953).—A comparison of the effects of intracaudal and subcutaneous vaccination of calves with *Brucella abortus,* strain 19. 4. A general assessment of results three years after vaccination. *Aust. Vet. J.* 29:117-21.

Gregory, T. S. (1952).—Intracaudal vaccination with *Brucella abortus,* strain 19. *Aust. Vet. J.* 28: 265-70.

Grigg, G. W. (1951).—The morphology of fowl spermatozoa. Proc. 9th World's Poult. Congr. 3 (Rep. 35):142-5.

Grigg, G. W. (1952).—Factors affecting the motility of fowl spermatozoa. Rep. 2nd Congr. Int. Physiol. Reprod. Anim. 1:87-96.

Grigg, G. W. (1952).—The morphology of fowl sperm. *Proc. Soc. Stud. Fertil.* No. 4:15-17.

Hardy, M. H. (1952).—The histochemistry of hair follicles in the mouse. *Amer. J. Anat.* 90:289-338.

Hardy, M. H., Fraser, A. S., *and* Short, B. F. (1952). —Spread of pigment in sheepskin autografts. *Nature.* 170:849.

Murnane, D. (1953).—Studies on bovine mastitis: the influence of milking-shed hygiene on the spread of infection by *Streptococcus agalactiae*. *Aust. Vet. J.* 29:70-2.

Reid, R. L. (1953).—Studies on the carbohydrate metabolism of sheep. VI. Interrelationships between changes in the distribution and levels of glucose and in the level of volatile fatty acid in the blood of lambs. *Aust. J. Agric. Res.* 4:213-23.

Riek, R. F., Roberts, F. H. S., *and* O'Sullivan, P. J. (1953).—Further observations on the epidemiology of parasitic gastro-enteritis of cattle. *Aust. Vet. J.* 29:122-8.

Roberts, F. H. S. (1952).—Host specificity of livestock parasites in Australia. *Aust. J. Sci.* 15:19-20.

Roberts, F. H. S. (1953).—The Australian species of *Aponomma* and *Amblyomma* (Ixodoidea). *Aust. J. Zool.* 1:111-61.

Roberts, N. F., *and* Wilson, L. T. (1952).—Counting pulses of various forms and occurrence intervals by electronic counters. *Aust. J. Appl. Sci.* 3:263-76.

Skaller, F. (1951).—Artificial insemination applied on a large scale to poultry-breeding research. Proc. 9th World's Poult. Congr. 3 (Rep. 30):124-9.

Sommerville, R. I. (1953).—Development of *Ostertagia circumcincta* in the abomasal mucosa of the sheep. *Nature.* 171:482-3.

Stewart, D. F. (1953).—Studies on resistance of sheep to infestation with *Haemonchus contortus* and *Trichostrongylus* spp. and on the immunological reactions of sheep exposed to infestation. V. The nature of the "self-cure" phenomenon. *Aust. J. Agric. Res.* 4:100-17.

Turner, A. W., *and* Hodgetts, V. E. (1952).—Depression of ruminal digestion in adult sheep by aureomycin. *Aust. J. Agric. Res.* 3:453-9.

Turner, H. G. (1953).—Dependence of residual milk in the udder of the cow upon total yield: its bearing upon supposed inhibition of secretion. *Aust. J. Agric. Res.* 4:118-26.

Whitfeld, P. R. (1952).—Nucleic acids in erythrocytic stages of a malaria parasite. *Nature.* 169:751-2.

Whitfeld, P. R. (1953).—Studies on the nucleic acids of the malaria parasite, *Plasmodium berghei* (Vincke and Lips). *Aust. J. Biol. Sci.* 6:234-43.

3. Atomic Physics.

(a) Physics Department, University of Melbourne.

Dyer, A. J. (1952).—The stopping power of Ilford C2 emulsion. *Aust. J. Sci. Res.* A 5:104-13.

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* Department of Chemistry, University of Sydney.

Dyer, A. J., *and* Bird, J. R. (1953).—Neutrons emitted in the deuteron disintegration of beryllium. *Aust. J. Phys.* 6:45-52.

Hirst, F. (1952).—Angular distribution of α-particles from the Li^7 $(p, \alpha)He^4$ reaction at low proton bombarding energies. *Aust. J. Sci. Res.* A 5:570-1.

Mather, K. B. (1952).—Proton-deuteron scattering at 5.1 MeV and deuteron-proton scattering at 10.2 MeV. *Phys. Rev.* 88:1408.

Parry, J. K., Rathgeber, H. D., *and* Rouse, J. L. (1953).—Ionisation of cosmic ray mesons in argon. *Proc. Phys. Soc. Lond.* A 66:541.

Spicer, B. M. (1952).—The absolute measurement of high-energy radiation. *Aust. J. Sci. Res.* A 5: 581-91.

Uebergang, R. G., *and* Tanner, N. W. (1953).—Angular correlation between α-particles and γ-rays in the $Be^9(d,\alpha)Li^{7*}\gamma Li^7$ reaction. *Aust. J. Phys.* 6:53-9.

(*b*) *Tracer Elements Investigations.*

Downes, A. M. (1952).—Isotope effect in the reaction of ^{14}C-formaldehyde with dimedone. *Aust. J. Sci. Res.* A 5:521-9.

(*c*) *Cosmic Ray Research, University of Tasmania.*

Burbury, D. W. P., *and* McLaren, A. C. (1952).—Cosmic ray asymmetry studies at Hobart, Tasmania. *Aust. J. Sci. Res.* A 5:782-4.

4. DIVISION OF BIOCHEMISTRY AND GENERAL NUTRITION.

Allen, Shirley H., *and* Hamilton, M. B. (1952).—The estimation of molybdenum and of tungsten by dithiol. *Analyt. Chim. Acta.* 7:483-93.

Dawbarn, Mary C., Hine, Denise C., *and* Hughes, Patricia (1952).—Influence of cobalt on the production of factors possessing Vitamin B_{12}-like activity in the faeces of sheep. *Nature.* 170:793.

Gray, F. V., *and* Pilgrim, A. F. (1952).—Origins of the volatile fatty acids in the rumen. *Nature.* 170:375.

Jarrett, I. G., *and* Potter, B. J. (1952).—Carbohydrate metabolism in the young lamb. *Aust. J. Exp. Biol. Med. Sci.* 30:207-12.

Jarrett, I. G., Potter, B. J., *and* Filsell, O. H. (1952).—Lower fatty acids in the intermediary metabolism of sheep. *Aust. J. Exp. Biol. Med. Sci.* 30: 197-206.

Jones, G. B. (1952).—The polarographic determination of copper and zinc in plants and soils. *Analyt. Chim. Acta.* 7:578-84.

Lee, H. J. (1953).—[Symposium] *Phalaris tuberosa* and phalaris staggers in sheep and cattle. The course of the disease. *J. Dep. Agric. S. Aust.* 56: 437.

Lee, H. J., *and* Kuchel, R. E. (1953).—[Symposium] *Phalaris tuberosa* and phalaris staggers in sheep and cattle. Investigational work on phalaris staggers in sheep. *J. Dep. Agric. S. Aust.* 56: 493-5.

Lee, H. J., *and* Kuchel, R. E. (1953).—The aetiology of phalaris staggers in sheep. I. Preliminary observations on the preventive role of cobalt. *Aust. J. Agric. Res.* 4:88-99.

Marston, H. R., *and* Lee, H. J. (1952).—Response of cobalt-deficient sheep to massive doses of vitamin B_{12}. *Nature.* 170:791.

Marston, H. R., *and* Smith, R. M. (1952).—Control of cobalt-deficiency in sheep by injection of vitamin B_{12}. *Nature.* 170:792.

Peirce, A. W. (1952).—Studies on fluorosis of sheep. I. The toxicity of water-borne fluoride for sheep maintained in pens. *Aust. J. Agric. Res.* 3:326-40.

Potter, B. J. (1952).—Relief of hypoglycaemic convulsions with butyric acid. *Nature.* 170:541.

Quinlan-Watson, T. A. F. (1953).—The effect of zinc deficiency on the aldolase activity in the leaves of oats and clover. *Biochem. J.* 53:457-60.

Riceman, D. S., *and* Powrie, J. K. (1952).—A comparative study of *Pisum, Vicia, Lathyrus,* and *Lupinus* varieties grown in Buckingham sand in the Coonalpyn Downs, South Australia. C.S.I.R.O. Aust. Bull. No. 269.

5. BIOPHYSICAL RESEARCH.

Hope, A. B., *and* Stevens, P. G. (1952).—Electric potential differences in bean roots and their relation to salt uptake. *Aust. J. Sci. Res.* B 5:335-43.

Hope, A. B. (1953).—Salt uptake by root tissue cytoplasm. *Aust. J. Biol. Sci.* 6:396-409.

Hope, A. B., *and* Robertson, R. N. (1953).——Bioelectric experiments and the properties of plant protoplasm. *Aust. J. Sci.* 15:197-203.

6. DIVISION OF BUILDING RESEARCH.

Blakey, F. A. (1952).—Comments on symposium on ultimate load design. *J. Amer. Concr. Inst.* 24:159-60.

Blakey, F. A. (1952).—Effect on concrete strength of curing in lime water. *Bull. R.I.L.E.M.* (10): 11-21.

Blakey, F. A. (1952).—Mechanism of fracture of concrete. *Nature.* 170:1120.

Blakey, F. A. (1953).—Alternative to the compression test for concrete. *Constr. Rev.* 26:17-19.

Blakey, F. A. (1953).—Flexural and tensile strength of concrete. *Constr. Rev.* 25:27-8.

Blakey, F. A. (1953).—Stress-strain curves for concrete. *Civ. Engng. Lond.* 48:57-8.

Carthew, A. R., *and* Cole, W. F. (1952).—Dispersion unit for clays. *J. Sci. Instrum.* 29:235.

Carthew, A. R., *and* Cole, W. F. (1953).—Apparatus for differential thermal analysis. *Aust. J. Instrum. Tech.* 9:23-30.

Cole, W. F. (1953).—A crystalline hydrated magnesium silicate formed in the breakdown of a concrete sea wall. *Nature.* 171:354.

Demediuk, T. (1952).—Method for overcoming "unsoundness" in magnesian limes. *Nature.* 170:799.

Hill, R. D. (1953).—Hardening of kaolin on rehydration. *Nature.* 171:567-8.

Langlands, I. (1952).—Conserving materials in building. *Aust. Builder.* 4:778-88.

Lippert, W. K. R. (1953).—The practical representation of standing waves in an acoustic impedance tube. *Acustica.* 3:153-60.

Muncey, R. W. (1953).—The calculation of temperatures inside buildings having variable external conditions. *Aust. J. Appl. Sci.* 4:189-96.

Muncey, R. W., *and* Waters, E. H. (1952-53).—Concrete floors for dwellings; survey of recent trends in America. *Architecture, Sydney.* 40 (3): 98-9. *Archit. Build. Engng.* 31:21-2.

Muncey, R. W., Nickson, A. F. B., *and* Dubout, P. (1953).—The acceptability of speech and music with a single artificial echo. *Acustica.* 3:168-73.

Nickson, A. F. B. (1952).—Accurate method of measuring frequency in the audio range. *J. Sci. Instrum.* 29:391-3.

Nickson, A. F. B., *and* Muncey, R. W. (1953).—Reverberation times of some Australian concert halls. *Aust. J. Appl. Sci.* 4:186-8.

Nickson, A. F. B., *and* Muncey, R. W. (1953).—Acoustic impedance measurement by the transmission-characteristic method. *Acustica.* 3:192-8.

Waters, E. H. (1952).—Modified soxhlet apparatus. *Chem. & Ind. (Rev.).* 1952:778-9.

Waters, E. H. (1952).—Discussion (New techniques in the study of setting and hardening of hydraulic materials. J. Calleja). *J. Amer. Concr. Inst.* 24:536/1-6.

7. Coal Research Section.

Brown, H. R., *and* Berry, H. (1953).—Some notes on the chemical characteristics and coking properties of some New South Wales coal seams. Publ. 5th Emp. Min. Metall. Cong., Australia and New Zealand 6:93.

Mapstone, G. E., *and* Smith, J. W. (1952).—Note on the permanganate titration of oxalic acid. *Chem. & Ind. (Rev.).* 1952:856.

8. Commonwealth Research Station (Murray Irrigation Areas).

Australia—Bureau of Agricultural Economics (1953).—Dehydration of vine fruits: joint report by Bureau of Agricultural Economics and Commonwealth Research Station, Merbein. (Bureau of Agricultural Economics, Department of Commerce and Agriculture: Canberra.)

9. Dairy Research Section.

Czulak, J. (1952).—Effects of bacteriophage infection of the cheese vat. *Aust. J. Dairy Tech.* 7:82-6.

Lee, J. W. (1952).—Skim milk powder for use in Australian bread. *Aust. J. Dairy Tech.* 7:118-25.

Loftus Hills, G. (1952).—Dairy research in Australia, 1947-1952. *Dairy Sci. Abstr.* 14:565-76.

Loftus Hills, G. (1952).—The production and utilization of milk solids in Australia. *J. Aust. Inst. Agric. Sci.* 18:130-4.

Pont, E. G. (1952).—Studies on the origin of oxidised flavour in whole milk. *J. Dairy Res.* 19:316-27.

10. Division of Electrotechnology.

Dryden, J. S. (1952).—Temperature dependence of the dielectric properties of long-chain aliphatic alcohols in the solid state. *Aust. J. Sci. Res.* A 5:661-70.

Dryden, J. S., *and* Meakins, R. J. (1953).—Electrical conductivity of certain crystalline materials after grinding. *Nature.* 171:307.

Hamon, B. V., *and* Meakins, R. J. (1952).—Dielectric absorption and D.C. conductivity in *n*-primary alcohols. *Aust. J. Sci. Res.* A 5:671-82.

Hamon, B. V., *and* Meakins, R. J. (1953).—Dielectric anisotropy in crystalline long-chain alcohols. *Aust. J. Chem.* 6:27-32.

Hollway, D. L., *and* Cassidy, G. J. A. (1952).—An instrument for dielectric measurements in the frequency range 100-300 Mc/s. *Proc. Instn. Elect. Engrs.* III. 99:364-72.

Hollway, D. L. (1952).—The optimum space-charge-controlled focus of an electron beam. *Aust. J. Sci. Res.* A 5:430-6.

Hollway, D. L. (1953).—A decimal counter electron tube. *Aust. J. Phys.* 6:96-115.

Lampard, D. G. (1952).—Harmonic and intermodulation distortion in "power law" devices. Instn. Elect. Engrs. Monograph No. 55.

Meakins, R. J. (1953).—The dielectric properties of crystalline alcohols containing sterically hindered hydroxyl groups. *Aust. J. Chem.* 6:104-8.

Murray, C. T., *and* Hollway, D. L. (1953).—Equipotential plotting, using untreated writing paper. *J. Appl. Phys.* 24:110.

O'Dwyer, J. J., *and* Sack, R. A. (1952).—The frequency dependence of the dielectric properties of dipolar substances. *Aust. J. Sci. Res.* A 5:647-60.

11. Division of Entomology.

Clark, L. R. (1953).—The ecology of *Chrysomela gemellata* Rossi and *C. hyperici* Forst., and their effect on St. John's wort in the Bright district, Victoria. *Aust. J. Zool.* 1:1-69.

Clark, L. R. (1953).—An analysis of the outbreaks of the Australian plague locust, *Chortoicetes terminifera* (Walker), during the seasons 1940-41 to 1944-45. *Aust. J. Zool.* 1:70-101.

Clark, Nancy (1953).—The biology of St. John's wort (*Hypericum perforatum* L. var. *angustifolium* DC) in the Ovens Valley, Victoria, with particular reference to entomological control. *Aust. J. Bot.* 1:95-120.

Common, I. F. B. (1952).—Migration and gregarious aestivation in the bogong moth, *Agrotis infusa.* *Nature.* 170:981-2.

Day, M. F., *and* Irzykiewicz, H. (1953).—Feeding behaviour of the aphids *Myzus persicae* and *Brevicoryne brassicae,* studied with radiophosphorus. *Aust. J. Biol. Sci.* 6:98-108.

Day, M. F., *and* Waterhouse, D. F. (1953).—Structure of the alimentary system. In "Insect Physiology". (Ed. K. D. Roeder.) pp. 273-98. (John Wiley & Sons: New York.)

Day, M. F., *and* Waterhouse, D. F. (1953).—Functions of the alimentary system. In "Insect Physiology". (Ed. K. D. Roeder.) pp. 299-310. (John Wiley & Sons: New York.)

Day, M. F., *and* Waterhouse, D. F. (1953).—The mechanism of digestion. In "Insect Physiology". (Ed. K. D. Roeder.) pp. 311-30. (John Wiley & Sons: New York.)

Fenner, F., *and* Day, M. F. (1952).—Contrasting methods of transmission of animal viruses by mosquitoes. *Nature.* 170:204.

Fenner, F., *and* Day, M. F. (1953).—Biological control of the rabbit. The use of myxomatosis in Australia. *Sci. News Hardmondsworth,* No. 27:7-22.

Fenner, F., Day, M. F., *and* Woodroofe, F. M. (1952).—The mechanism of the transmission of myxomatosis in the European rabbit *Oryctolagus cuniculus* by the mosquito *Aedes aegypti.* *Aust. J. Exp. Biol. Med. Sci.* 30:139-52.

Forte, P. N., *and* Greaves, T. (1953).—New insecticides for the control of the Argentine ant in Western Australia. *J. Dep. Agric. W. Aust.* 2:267-80.

Gay, F. J. (1953).—Report of laboratory tests to determine the resistance to termite attack of certain Malayan commercial timbers. *Malay. Forester.* 16:45-9.

Gay, F. J. (1953).—Some observations on the biology of *Lyctus brunneus* (Steph.). *Aust. J. Zool.* 1:102-10.

Gilmour, D. (1953).—The biochemistry of muscle. In "Insect Physiology". (Ed. K. D. Roeder.) pp. 402-22. (John Wiley & Sons: New York.)

Gilmour, D., *and* Calaby, J. H. (1952).—The magnesium activated apyrase of insect muscle. *Arch. Biochem.* 41:83-103.

Hackman, R. H. (1952).—Green pigments in the haemolymph of insects. *Arch. Biochem.* 41: 166-74.

Hackman, R. H., *and* Trikojus, V. M. (1952).—The composition of the honeydew excreted by Australian coccids of the genus *Ceroplastes*. *Biochem. J.* 51:653-6.

Key, K. H. L. (1952).—A provisional check-list of the Acridoidea of Tasmania (Orthoptera). *Pap. Roy. Soc. Tas.* 86:127-30.

Mercer, E. H., *and* Day, M. F. (1952).—The fine structure of the peritrophic membranes of certain insects. *Biol. Bull.* 103:384-94.

Paramonov, S. J. (1953).—Notes on Australian Diptera. IX. The description of the adult *Tracheomyia macropi* Frog. First endemic Australian Oestrid. *Ann. Mag. Nat. Hist.* 6:195-9.

Paramonov, S. J. (1953).—Notes on Australian Diptera. X. A note on the genus *Phellus* Wlk. (Asilidae). *Ann. Mag. Nat. Hist.* 6:199-204.

Paramonov, S. J. (1953).—Notes on Australian Diptera. XI. A new species of *Antonia* (Bombyliidae). *Ann. Mag. Nat. Hist.* 6:204-5.

Paramonov, S. J. (1953).—Notes on Australian Diptera. XII. Note on the genus *Euthera* (Tachinidae). *Ann. Mag. Nat. Hist.* 6:206-8.

Powning, R. F. (1953).—Studies on the digestion of wool by insects. VIII. The significance of certain excretory products of the clothes moth, *Tineola bisselliella*, and the carpet beetle, *Attagenus piceus*. *Aust. J. Biol. Sci.* 6:109-17.

Ratcliffe, F. M., Gay, F. J., *and* Greaves, T. (1952).—"Australian Termites". pp. 124. (C.S.I.R.O.: Melbourne.)

Waterhouse, D. F. (1952).—Studies on the digestion of wool by insects. VII. Some features of digestion in three species of dermestid larvae and a comparison with *Tineola* larvae. *Aust. J. Sci. Res.* B 5:444-59.

Waterhouse, D. F. (1953).—Studies on the digestion of wool by insects. IX. Some features of digestion in chewing lice (Mallophaga) from bird and mammalian hosts. *Aust. J. Biol. Sci.* 6:257-75.

Waterhouse, D. F., *and* Day, M. F. (1953).—Function of the gut in absorption. In "Insect Physiology". (Ed. K. D. Roeder.) pp. 350-86. (John Wiley & Sons: New York.)

Wilson, F. (1952).—The biological control of weeds in Australia. *Proc. 6th Int. Grassld. Congr.*

12. Division of Fisheries.

Blackburn, M. (1953).—Problems and fallacies in the management of fish stocks in Australia. *Aust. J. Sci.* 15:151-4.

Fairbridge, W. S. (1953).—A population study of the Tasmanian "commercial" scallop *Notovola meridionalis* (Tate). *Aust. J. Mar. Freshw. Res.* 4: 1-40.

Kott, Patricia (1952).—The Ascidians of Australia. I. Stolidobranchiata Lahille and Phlebobranchiata Lahille. *Aust. J. Mar. Freshw. Res.* 3:205-333.

Olsen, A. M. (1953).—Tagging of school shark, *Galeorhinus australis* (Macleay) (Carcharhanidae) in south-eastern Australian waters. *Aust. J. Mar. Freshw. Res.* 4:95-104.

Rapson, M. (1952).—The toheroa, *Amphidesma ventricosum* Gray (Eulamellibranchiata), development and growth. *Aust. J. Mar. Freshw. Res.* 3: 170-98.

Robins, J. P. (1952).—Further observations on the distribution of striped tuna, *Katsuwonus pelamis* L., in eastern Australian waters, and its relation to surface temperature. *Aust. J. Mar. Freshw. Res.* 3:101-10.

Rochford, D. J. (1951).—A comparison of the hydrological conditions off the eastern and western coasts of Australia. *Proc. I.P.F.C.* 1951: 61-8.

Rochford, D. J. (1952).—Oceanographical Station list of investigations made by the Division of Fisheries, C.S.I.R.O., Aust., Vols. 5-7, 9-12.

Rochford, D. J. (1952).—The application of studies on estuarine hydrology to certain problems in Australian oyster biology. *Rapp. Cons. Explor. Mer.* 131:35-7.

Sheard, K. (1953).—Plankton of the Australian Antarctic Quadrant. Pt. 11. Taxonomy, Distribution. Growth and Relative Growth in the Euphausiacea (Crustacea). B.A.N.Z. Antarct. Res. Exped. 1929-31, Repts. Ser. B. 6 (3):1-80.

Spencer, R. (1952).—Oceanographical Station list of investigations made by the Division of Fisheries, C.S.I.R.O., Aust. Vol. 8.

Thomson, J. M. (1953).—Status of the fishery for sea mullet (*Mugil cephalus* Linnaeus) in eastern Australia. *Aust. J. Mar. Freshw. Res.* 4: 41-81.

Wood, E. J. F. (1953).—Heterotrophic bacteria in marine environments of eastern Australia. *Aust. J. Mar. Freshw. Res.* 4:160-200.

13. Division of Food Preservation and Transport.

Beard, P. (1953).—Storage and ripening of canning peaches. *Agric. Gaz. N.S.W.* 64:7-8. Also published as: Cool storage of clingstone peaches. *Food Pres. Quart.* 13:10-12.

Bryant, F.*, *and* Overell, B. T. (1953).—Quantitative chromatographic analysis of organic acids in plant tissue extracts. *Biochim. Biophys. Acta.* 10: 471-6.

Empey, W. A. (1951).—Notes on the influence of nitrite on the quality of canned cured meats. *Food Pres. Quart.* 11: 39-45.

Farrant, J. L.,† Robertson, R. N., *and* Wilkins, M. J. (1953).—The mitochondrial membrane. *Nature.* 171:401.

Huelin, F. E. (1952).—Volatile products of apples. III. Identification of aldehydes and ketones. *Aust. J. Sci Res.* B 5:328-34.

Kefford, J. F., Chandler, B. V., *and* Lynch, L. J. (1952).—The influence of rootstocks on the quality of canned orange juice. *Food Pres. Quart.* 12:26-9.

Lynch, L. J., *and* Mitchell, R. S. (1952).—Short-term prediction of maturity and yield of canning peas. *Food Tech., Champaign.* 6(9):24.

Mitchell, R. S., *and* Lynch, L. J. (1952).—Maturity prediction for peas. *Proc. Inst. Fd. Tech. Aust. Region. Sect. Ann. Conv.* 2:13-16.

Mitchell, R. S., *and* Lynch, L. J. (1952).—The Maturometer, an instrument for the objective assessment of maturity in canning peas. *Food Tech. Aust.* 4: 195-6.

Ohye, D. F., *and* Scott, W. J. (1953).—The temperature relations of *Clostridium botulinum*, types A and B. *Aust. J. Biol. Sci.* 6:178-89.

---

* Research Laboratory, Prestige Ltd., Melbourne.
† Division of Industrial Chemistry, C.S.I.R.O.

Overell, B. T. (1952).—A toxin in culture filtrates of *Sclerotinia sclerotiorum*. *Aust. J. Sci.* 14:197-8.

Overell, B. T. (1952).—Quantitative and two-dimensional paper chromatography of organic acids. *Aust. J. Sci.* 15:28-9.

Pearson, Judith A., *and* Robertson, R. N. (1952).—The climacteric rise in respiration of fruit. *Aust. J. Sci.* 15:99-100.

Pearson, Judith A., *and* Robertson, R. N. (1953).—The physiology of growth in apple fruits. IV. Seasonal variation in cell size, nitrogen metabolism, and respiration in developing Granny Smith apple fruits. *Aust. J. Biol. Sci.* 6:1-20.

Rostos, G. M., *and* Hicks, E. W. (1952).—Some observations on the design of cool stores. *Refrig. J.* 6(3):25-31.

Trout, S. A., Hall, E. G., *and* Sykes, S. M. (1953).—Effects of skin coatings on the behaviour of apples in storage. I. *Aust. J. Agric. Res.* 4:57-81.

Vickery, J. R. (1952).—Preparation and cooling of meat for local consumption. *Refrig. J.* 6(3):36, 38-9.

14. DIVISION OF FOREST PRODUCTS.

Amos, G. L. (1952).—Silica in timbers. C.S.I.R.O. Aust. Bull. No. 267.

Chattaway, M. Margaret (1952).—Sapwood-heartwood transition. *Aust. For.* 16:25-34.

Chattaway, M. Margaret (1953).—Occurrence of heartwood crystals in certain timbers. *Aust. J. Bot.* 1:27-38.

Christensen, G. N., *and* Barkas, W. W. (1953).—Physical properties of paper pulps; elastic properties of wet mats of paper-making fibres. *Nature.* 171:165.

Clarke, L. N. (1953).—Timbers for battery separators. C.S.I.R.O. Aust. Bull. No. 271.

Cooper, K. L. (1953).—Preferred stress grades for structural timber. *Aust. J. Appl. Sci.* 4:77-83.

Foster, D. H. (1952).—Reactivity of wood cellulose. Treatment with dilute sulphuric acid at elevated temperatures. *Proc. Aust. Pulp Ind. Tech. Ass.* 6:76-88.

Grossman, P. U. A. (1953).—Recovery of plywood after compression at elevated temperatures. *Aust. J. Appl. Sci.* 4:98-106.

Higgins, H. G. (1953).—Factors influencing the plastic deformation of timber and plywood in compression. *Aust. J. Appl. Sci.* 4:84-97.

Higgins, H. G., *and* Fraser, D. (1952).—Reaction of amino acids and proteins with diazonium compounds. I. A spectrophotometric study of azo-derivatives of histidine and tyrosine. *Aust. J. Sci. Res.* A 5:736-53.

Higgins, H. G., Fraser, D., *and* Hayes, J. F. (1952).—Role of the sulphydryl group in the formation of alkaline protein gels. *Nature.* 169:1020-1.

Higgins, H. G., *and* Williams, E. J. (1952).—Kinetic treatment appropriate to rapid reactions involving two consecutive second order steps. *Aust. J. Sci. Res.* A 5:572-6.

Hillis, W. E. (1953).—Chromatographic examination of the minor constituents of various tree zones. *J. Sci. Fd. Agric.* 4:135-48.

Ingle, H. D., *and* Dadswell, H. E. (1953).—Anatomy of the timbers of the south-west Pacific area. II. Apocynaceae and Annonaceae. *Aust. J. Bot.* 1:1-26.

Kingston, R. S. T. (1953).—Mechanical and physical properties of hoop and bunya pines. *Aust. J. Appl. Sci.* 4:197-234.

Kloot, N. H. (1952).—Mechanical and physical properties of coconut palm. *Aust. J. Appl. Sci.* 3:293-323.

Kloot, N. H. (1953).—Impact hardness tests on wood. I. The effects of machine variables. *Aust. J. Appl. Sci.* 4:65-76.

Stewart, C. M. (1953).—Preparation of invertase solution. *Aust. J. Sci.* 15:134-5.

Stewart, C. M., *and* Foster, D. H. (1953).—Identification of 4-methyl-D-glucuronic acid in *Eucalyptus regnans* wood. *Nature.* 171:792.

Stewart, C. M., Amos, G. L., *and* Harvey, L. Josephine (1953).—Chemical studies on *Eucalyptus regnans* F.v.M. *Aust. J. Biol. Sci.* 6:21-47.

Turnbull, R. F. (1952).—Sawing chains. *Aust. Timb. J.* 18:661-2, 664, 667, 669, 671, 673.

Wardrop, A. B. (1952).—Formation of new cell walls in cell division. *Nature.* 170:329.

Wardrop, A. B., *and* Dadswell, H. E. (1952).—Nature of reaction wood. III. Cell division and cell wall formation in conifer stems. *Aust. J. Sci. Res.* B 5:385-98.

Watson, A. J., Wardrop, A. B., Dadswell, H. E., *and* Cohen, W. E. (1952).—Influence of fibre structure on pulp and paper properties. *Proc. Aust. Pulp Ind. Tech. Ass.* 6:243-69.

Williams, E. J.,* *and* Kloot, N. H. (1953).—Interpolation in a series of correlated observations. *Aust. J. Appl. Sci.* 4:1-17.

Wright, G. W. (1952).—Plant installation and drying costs for timber seasoning kilns. *Aust. Timb. J.* 18:651-2, 655, 657-9, 661.

15. DIVISION OF INDUSTRIAL CHEMISTRY.

Alderman, A. R. (1952).—Mount Fitton talc as a possible source of forsterite refractories. In "Sir Douglas Mawson Anniversary Volume". pp. 1-6. (Univ. Adelaide: Adelaide.)

Alexander, K. M. (1953).—Pozzolanas. I. A procedure for the reproducible determination of pozzolanic reactivity. *Aust. J. Appl. Sci.* 4:146.

Asker, W. J., Segnit, E. R., *and* Wylie, A. W. (1952).—The potassium thorium fluorides. *J. Chem. Soc.* 1952:4470.

Barker, J. A. (1952).—Co-operative orientation effects in solutions. *J. Chem. Phys.* 20:1526.

Barker, J. A. (1953).—Methods of approximation in the theory of regular mixtures. *Proc. Roy. Soc.* A 216:45.

Barker, J. A., Brown, I., *and* Smith, F. (1953).—Thermodynamic properties of alcohol solutions: the system ethanol + carbon tetrachloride. *Disc. Faraday Soc.* 15:142.

Barker, J. A., *and* Fock, W. (1953).—Theory of upper and lower critical solution temperatures. *Disc. Faraday Soc.* 15:188.

Barnes, C. S., Barton, D. H. R., Cole, A. R. H., Fawcett, J. S., *and* Thomas, B. R. (1953).—Triterpenoids. IX. The constitution of lanostadienol. *J. Chem. Soc.* 1953:571.

Barnes, C. S., Barton, D. H. R., Fawcett, J. S., *and* Thomas, B. R. (1952).—Triterpenoids. VII. Some further observations on the constitution of lanostadienol. *J. Chem. Soc.* 1952:2339.

Barnes, C. S., Barton, D. H. R., Fawcett, J. S., *and* Thomas, B. R. (1953).—Triterpenoids. X. The stereochemistry of lanostadienol. *J. Chem. Soc.* 1953:576.

Bayliss, N. S., *and* Koch, D. F. A. (1952).—Investigation of the Engel-Precht method for the production of potassium carbonate. *Aust. J. Appl. Sci.* 3:237.

Beckett, Roberta J., *and* Croft, R. C. (1952).—The structure of graphite oxide. *J. Phys. Chem.* 56:929.

---

* Section of Mathematical Statistics, C.S.I.R.O.

bury, R. B., *and* White, D. E. (1953).—The chemistry of subterranean clover. Part II. Synthesis and reduction of isoflavones related to genistein and formononetin. *J. Chem. Soc.* 1953: 871.

pane, S. M., *and* Segnit, E. R. (1953).—The action of potash on high alumina refractories in cement kilns. *Aust J. Appl. Sci.* 4:158.

pane, S. M., *and* Segnit, E. R. (1953).—Action of potash on magnesite-chrome refractories in cement kilns. *Aust. J. Appl. Sci.* 4:335.

vn, I. (1952).—Liquid vapour equilibria. III. The systems benzene-*n*-heptane, *n*-hexane-chlorobenzene, and *cyclo*hexane-nitrobenzene. *Aust. J. Sci. Res.* A 5:530.

ıon, J. R., Hughes, G. K., Price, J. R., *and* Ritchie, E. (1952).—Chemical constituents of Australian *Flindersia* species. IV. The constituents of *Flindersia bourjotiana* F. Muell. *Aust. J. Sci. Res.* A 5:420.

an, C. K., *and* Rees, A. L. G. (1952).—The nature of the thermal colour change in zinc oxide. *J. Chem. Phys.* 20:1650.

ey, J. M. (1953).—Electron diffraction study of the hydrogen bonds in boric acid. *Nature.* 171: 440.

ey, J. M. (1953).—Stacking faults in γ-alumina. *Acta Cryst. Camb.* 6:53.

ey, J. M. (1953).—Structure analysis of single crystals by electron diffraction. 1. Techniques. *Acta Cryst. Camb.* 6:516.

ley, J. M. (1953).—Structure analysis of single crystals by electron diffraction. 2. Disordered boric acid structure. *Acta Cryst. Camb.* 6:522.

ley, J. M., *and* Rees, A. L. G. (1953).—Design of a high resolution electron diffraction camera. *J. Sci. Instrum.* 30:33.

t, R. C. (1952).—The separation of the anhydrous chlorides of iron and aluminium by formation of graphite complexes. *J. Appl. Chem.* 2:557.

t, R. C. (1952).—The reaction between ferric oxide and anhydrous aluminium chloride. *J. Appl. Chem.* 2:562.

t, R. C., Skewes, H. R., *and* Walkley, A. (1952).—The suitability of manganese dioxides and graphites for use in Leclanché-type dry cells. II. The performance of graphites in Leclanché-type dry cells: the effect of carbon content, carbon structure, and particle size. *Aust. J. Appl. Sci.* 3:338.

t, R. C., Skewes, H. R., *and* Walkley, A. (1952).—The suitability of manganese dioxides and graphites for use in Leclanché-type dry cells. III. The performance of graphites in Leclanché-type dry cells: the effect of accessory minerals and of other substances on shelf life. *Aust. J. Appl. Sci.* 3:355.

v, W. D., Haworth, R. D., *and* Jefferies, P. R. (1952).—Purpurogallin. X. Further studies on the oxidation products of purpurogallin and purpurogallin-carboxylic acid. *J. Chem. Soc.* 1952: 3705.

en, G. V. (1953).—An automatic apparatus for recording evolution of gas from foundry cores. *Aust. J. Appl. Sci.* 4:58.

enor, C. C. J. (1953).—Amine oxides. *Rev. Pure Appl. Chem.* 3:83.

is, R. G., Fridrichsons, J., *and* Mathieson, A. McL. (1952).—The structure of lanostenol. *Nature.* 170:321.

tis, R. G., Heilbron, I., Jones, E. H. R., *and* Woods, G. F. (1953).—The further characterization of polyporanic acid. *J. Chem. Soc.* 1953: 457.

Dalton, L. K. (1953).—Resins from sulphited tannins as adhesives for wood. *Aust. J. Appl. Sci.* 4:136.

David, H. G., Hamann, S. D., *and* Pearse, J. F. (1952).—The dielectric properties of compressed fluoromethane. *J. Chem. Phys.* 20:969.

David, H. G., Hamann, S. D., *and* Prince, R. G. (1952).—The third virial coefficient of ethane. *J. Chem. Phys.* 20:1973.

Dawson, B. (1953).—The crystal structure of DL-glutamic acid hydrochloride. *Acta Cryst. Camb.* 6:81.

Dawson, B. (1953).—The structure of the 9(18)-heteropoly anion in potassium 9(18)-tungstophosphate, $K_6(P_2W_{18}O_{62}).14H_2O$. *Acta Cryst. Camb.* 6:113.

Evans, L. F. (1953).—The flotation of topaz using sodium hexadecyl sulphate as collector. *Aust. J. Appl. Sci.* 4:165.

Evans, L. F., *and* Ewers, W. E. (1952).—The process of bubble-mineral attachment. Symposium on mineral dressing, Sept., 1952. Inst. Min. Met. Lond. Paper No. 23.

Ewers, W. E., *and* Sutherland, K. L. (1952).—The role of surface transport in the stability and breakdown of foams. *Aust. J. Sci. Res.* A 5:697.

Farrant, J. L., *and* Fenner, F. (1953).—A comparison of the morphology of vaccinia and myxoma viruses. *Aust. J. Exp. Biol. Med. Sci.* 31:121.

Farrant, J. L., *and* Mercer, E. H. (1952).—Studies on the structure of muscle. 2. Arthropod muscles. *Exp. Cell Res.* 3:553.

Farrant, J. L., Robertson, R. N., *and* Wilkins, M. J. (1953).—The mitochondrial membrane. *Nature.* 171:401.

Francis, P. G., McGlashan, M. L., Hamann, S. D., *and* McManamey, W. J. (1952).—The second virial coefficient of benzene. *J. Chem. Phys.* 20:1341.

Garten, V. A. (1953).—Styrol-polymerization in gegenwart von sulphonamiden und para-aminobenzoesaure (pabs.). *Z. Naturf.(B).* 8b:46.

Ham, N. S., Rees, A. L. G., *and* Walsh, A. (1952).—The infra-red spectra of solutions of iodine in mesitylene. *J. Chem. Phys.* 20:1336.

Ham, N. S., Walsh, A., *and* Willis, J. B. (1952).—Multiple monochromators. 3. A quadruple monochromator and its application to infra-red spectroscopy. *J. Opt. Soc. Amer.* 42:496.

Hamann, S. D., *and* McManamey, W. J. (1953).—The second virial coefficient of ethane. *Trans. Faraday Soc.* 49:149.

Hamann, S. D., McManamey, W. J., *and* Pearse, J. F. (1953).—The forces between polyatomic molecules. *Trans. Faraday Soc.* 49:351.

Hancox, N. C. (1953).—The reaction between acetone and ammonia. III. Reduced pyridine derivatives. *Aust. J. Chem.* 6:143.

Hardy, D. V. M., *and* Hatt, H. H. (1952).—The formation of triarylmethylphosphonic acids from triarylmethylphosphonium dichlorides. *J. Chem. Soc.* 1952:3778.

Hatt, H. H., *and* Lamberton, J. A. (1953).—Sugar cane wax. The effect of chemical modification upon the physical properties. Studies in waxes, part VII. *Proc. Qd. Soc. Sug. Cane Tech.* 20: 29.

Haynes, H. F., Nelson, Eva R., *and* Price, J. R. (1952).—Alkaloids of the Australian Rutaceae: *Pentaceras australis* Hook f. I. Isolation of the alkaloids and identification of canthin-6-one. *Aust. J. Sci. Res.* A 5:387.

Herington, E. F. G., *and* Murray, K. E. (1952).—An apparatus for the determination of chemical purity by the solubility criterion using differential vapour pressure measurements. *Research.* 5:491.

Ingles, O. G. (1952).—The water-gas-shift reaction in fuel systems. Part I. The water-gas-shift on carbon. *Trans. Faraday Soc.* 48 : 706.

Lamberton, J. A., *and* Price, J. R. (1953).—Alkaloids of the Australian Rutaceae: *Acronychia baueri* Schott. IV. Alkaloids present in the leaves. *Aust. J. Chem.* 6 : 66.

Lamberton, J. A., *and* Price, J. R. (1953).—Alkaloids of the Australian Rutaceae: *Medicosma cunninghamii* Hook f. *Aust. J. Chem.* 6 : 173.

McGowan, J. K., *and* Vivian, H. E. (1952).—Studies in cement-aggregate reaction. XX. The correlation between crack development and expansion of mortar. *Aust. J. Appl. Sci.* 3 : 228.

McKenzie, A. W., *and* Price, J. R. (1952).—Alkaloids of the Australian Rutaceae: *Glycosmis pentaphylla* (Retz.) Correa. *Aust. J. Sci. Res.* A 5 : 579.

McKenzie, A. W., *and* Price, J. R. (1953).—The alkaloids of *Gryocarpus americanus* Jacq. *Aust. J. Chem.* 6 : 180.

Mansfield, W. W. (1952).—The spontaneous emulsification of mixtures of oleic acid and paraffin oil in alkaline solutions. *Aust. J. Sci. Res.* 5 : 331.

Mathieson, A. McL. (1953).—The polymorphism of DL-norleucine. *Acta Cryst. Camb.* 6 : 399.

Mathieson, A. McL., *and* Walker, G. F. (1952).—The structure of vermiculite. *Clay Minerals Bull.* 1 : 272.

Mathieson, A. McL., *and* Welsh, H. K. (1952).—The crystal structure of copper proline dihydrate. *Acta Cryst. Camb.* 5 : 599.

Mercer, E. H. (1952).—The fine structure and biosynthesis of silk fibroin. *Aust. J. Sci. Res.* B 5 : 366.

Mercer, E. H. (1952).—Observations on the molecular structure of byssus fibres. *Aust. J. Mar. Freshw. Res.* 3 : 199.

Mercer, E. H. (1952).—The supercontraction of keratin. *Textile Res. J.* 22 : 476.

Mercer, E. H. (1953).—Modification in the surface of wool fibres produced by chemical treatments: an electron microscope study. *Aust. J. Appl. Sci.* 4 : 107.

Mercer, E. H., *and* Day, M. F. (1952).—The fine structure of the peritrophic membranes of certain insects. *Biol. Bull.* 103 : 384.

Murray, K. E., *and* Schoenfeld, R. (1952).—Studies in waxes. V. The aliphatic alcohols of wool wax. *J. Amer. Oil Chem. Soc.* 29 : 416.

Murray, K. E., *and* Schoenfeld, R. (1953).—Studies of waxes. VI. The *n* acids of carnauba wax. *J. Amer. Oil Chem. Soc.* 30 : 25.

Nelson, Eva R., *and* Price, J. R. (1952).—Alkaloids of the Australian Rutaceae: *Pentaceras australis* Hook f. II. Identification of 5-methoxycanthinone. *Aust. J. Sci. Res.* A 5 : 563.

Nelson, Eva R., *and* Price, J. R. (1952).—Alkaloids of the Australian Rutaceae: *Pentaceras australis* Hook f. III. Identification of 4-methylthiocanthin-6-one. *Aust. J. Sci. Res.* A 5 : 768.

Nicholson, A. J. C. (1952).—The stability of the acetyl radical. *J. Chem. Phys.* 20 : 1811.

Nicholson, A. J. C. (1952).—The photolysis of the aliphatic aldehydes and ketones. *Rev. Pure Appl. Chem.* 2 : 74.

Onat, E., *and* Parts, A. G. (1952).—Hydrogen peroxide decomposition catalysed by ferric salts. *Aust. J. Sci.* 15 : 30.

Parts, A. G. (1952).—The water-gas-shift equilibrium in the gasification of lignite with steam. *Aust. J. Appl. Sci.* 3 : 257.

Rees, A. L. G. (1953).—Electron diffraction in the chemistry of the solid state. *J. Roy. Soc. N.S.W.* 86 : 38.

Rideal, E. K., *and* Sutherland, K. L. (1952).—The variation of the surface tension of solutions with time. Solutions of alcohols. *Trans. Faraday Soc.* 48 : 1109.

Segnit, E. R., *and* Wolfe, J. D. (1953).—High temperature silicate chemistry at Division of Industrial Chemistry, C.S.I.R.O. *Chem. Engng. Min. Rev.* 45 : 215.

Skewes, H. R., Wadsley, A. D., *and* Walkley, A. (1952).—The suitability of manganese dioxides and graphites for use in Leclanché-type dry cells. IV. The behaviour of manganese oxides in Leclanché-type dry cells. *Aust. J. Appl. Sci.* 3 : 368.

Skewes, H. R., *and* Walkley, A. (1952).—The significance of structure on the electroreduction of manganese dioxide. C.R. Int. Comm. Electrochem. Kinetics, Cambridge, England, September, 1952.

Stephens, H. A. (1952).—A study of the A.F.S. fineness test. *Trans. Amer. Foundrym. Ass.* 60 : 53.

Sutherland, K. L. (1952).—The kinetics of adsorption at liquid surfaces. *Aust. J. Sci. Res.* A 5 : 683.

Swinton, E. A., *and* Weiss, D. E. (1953).—Countercurrent adsorption separation processes. I. Equipment. *Aust. J. Appl. Sci.* 4 : 316.

Vickery, R. C. (1952).—Ion exchange elution series. *Nature.* 170 : 665.

Vickery, R. C. (1952).—Separation of the lanthanons by ion exchange. A comparison of eluants. *J. Chem. Soc.* 1952 : 4357.

Wadsley, A. D. (1952).—Role of water in the structure of psilomelane $(Ba,H_2O)_2Mn_5O_{10}$. *Nature.* 170 : 973.

Wadsley, A. D. (1952).—The structure of lithiophorite $(Al,Li)MnO_2(OH)_2$. *Acta Cryst. Camb.* 5 : 676.

Wadsley, A. D. (1953).—The crystal structure of psilomelane $(Ba,H_2O)_2Mn_5O_{10}$. *Acta Cryst. Camb.* 6 : 433.

Wadsley, A. D., *and* Walkley, A. (1952).—The reactivity of manganese dioxide. *Proc. Int. Conf. Reactivity of Solids, Gothenburg, Sweden, June,* 1952.

Walkley, A. (1952).—The suitability of manganese dioxides and graphites for use in Leclanché-type dry cells. I. A review of problems met with in research in Leclanché-type dry cells, and their active constituents. *Aust. J. Appl. Sci.* 3 : 324.

Walkley, A. (1952).—The potential and coulombic capacity of some galvanic cell systems. *J. Electrochem. Soc.* 99 : 209c.

Walsh, A. (1953).—Reduction of scattered light in a Littrow-type monochromator. *J. Opt. Soc. Amer.* 43 : 58.

Walsh, A. (1953).—Design of double beam multiple monochromators. *J. Opt. Soc. Amer.* 43 : 215.

Walsh, A. (1953).—Multiple monochromator. Aust. Pat. Application 18,212/53.

Walsh, A. (1953).—Multiple monochromator. Aust. Pat. 148,338; U.S. Pat. 240,737; G. B. Pat. 682,149; Ital. Pat. 478/984.

Weymouth, J. H., *and* Williamson, W. O. (1952).—Some effects of processing operations on the porosity of earthenware and related bodies. *Trans. Brit. Ceram. Soc.* 51 : 489.

Weymouth, J. H., *and* Williamson, W. O. (1953).—The effects of extrusion and some other processes on the microstructure of clay. *Amer. J. Sci.* 251 : 89.

Wilson, B. W. (1952).—The sedimentation of dilute suspensions of microscopic spheres in water. *Aust. J. Appl. Sci.* 3 : 252.

Wilson, B. W. (1953).—The turbocyclone: a new method for separating fine particles from gas streams. *Aust. J. Appl. Sci.* 4 : 47.

Wilson, B. W. (1953).—The permeability of beds of microscopic spheres. *Aust. J. Appl. Sci.* 4 : 300.

Wilson, B. W. (1953).—The sedimentation of dense suspensions of microscopic spheres. *Aust. J. Appl. Sci.* 4:274.

Zimmerman, W. (1952).—Zur mikromassanalytischen Schnellbestimmung des Schwefels in organischen und anorganischen Substanzen (4 Mitteilung). *Mikrochemie.* 40:162.

16. IRRIGATION RESEARCH STATION (MURRUMBIDGEE IRRIGATION AREAS).

Frith, H. J. (1952).—Some effects of no cultivation on the yield and growth of citrus trees. *Aust. J. Agric. Res.* 3:259-76.

Greacen, E. L., *and* Huon, A. N. (1953).—Microscopic changes in soil aggregates during permeability tests. *Aust. J. Agric. Res.* 4:184-92.

Greacen, E. L., *and* Perkman, O. (1953).—Soil-structure changes in a long-term citrus experiment. *Aust. J. Agric. Res.* 4:193-203.

West, E. S., *and* Howard, A. (1953).—Movement of salts in isolated soil columns.—*Aust. J. Agric. Res.* 4:82-7.

17. LAND RESEARCH AND REGIONAL SURVEY SECTION.

Blake, S. T.* (1953).—Botanical contributions of the Northern Australia Regional Survey. I. Studies on northern Australian species of *Eucalyptus*. *Aust. J. Bot.* 1:185-352.

Christian, C. S. (1952).—Regional land surveys. *J. Aust. Inst. Agric. Sci.* 18:140-6.

Christian, C. S. (1953).—Introduction to survey of the Townsville-Bowen region. C.S.I.R.O. Aust. Land Res. Ser. No. 2, Part I.

Christian, C. S. (1952).—Introduction to survey of the Barkly region. C.S.I.R.O. Aust. Land Res. Ser. No. 3, Part I.

Christian, C. S., *and* Perry, R. A. (1953).—The systematic description of plant communities by the use of symbols. *J. Ecol.* 41:100-5.

Christian, C. S., *and* Slatyer, R. O. (1953).—Climate in relation to agriculture in the Townsville-Bowen region. C.S.I.R.O. Aust. Land Res. Ser. No. 2, Part II.

Christian, C. S., *and* Stewart, G. A. (1952).—General report on survey of Katherine-Darwin region, 1946. C.S.I.R.O. Aust. Land. Res. Ser. No. 1.

Christian, C. S., *and* Stewart, G. A. (1952).—The land-use groups of the Barkly region. C.S.I.R.O. Aust. Land. Res. Ser. No. 3, Part IX.

Christian, C. S., *and* Stewart, G. A. (1953).—Land-use groups of the Townsville-Bowen region and their potentialities. C.S.I.R.O. Aust. Land Res. Ser. No. 2, Part VIII.

Perry, R. A. (1953).—The vegetation communities of the Townsville-Bowen region. C.S.I.R.O. Aust. Land Res. Ser. No. 2, Part VI.

Stewart, G. A. (1953).—Soils of the Townsville-Bowen region and their agricultural characteristics. C.S.I.R.O. Aust. Land. Res. Ser. No. 2, Part V.

Stewart, G. A., *and* Perry, R. A. (1953).—The land systems of the Townsville-Bowen region. C.S.I.R.O. Aust. Land. Res. Ser. No. 2, Part VII.

Stewart, G. A., Traves, D. M., *and* Paterson, S. J. (1953).—Outline of the geomorphology of the Townsville-Bowen region. C.S.I.R.O. Aust. Land Res. Ser. No. 2, Part IV.

18. SECTION OF MATHEMATICAL INSTRUMENTS.

Blunden, W. R., Keith, R. J., *and* Speedy, C. B. (1953).—The application of electronic techniques to high speed digital computors. *J. Inst. Engrs. Aust.* 25:11-18.

Myers, D. M., *and* Blunden, W. R. (1952).—The C.S.I.R.O. differential analyser. *J. Inst. Engrs. Aust.* 24: 195-204.

Wittrick, W. H., Myers, D. M., *and* Blunden, W. R. (1953).—Stability of a bimetallic disk. Pt. II. *Quart. J. Mech.* 6:15.

19. SECTION OF MATHEMATICAL STATISTICS.

Higgins, H. G., *and* Williams, E. J. (1952).—Kinetic treatment appropriate to rapid reactions involving two consecutive second order steps. *Aust. J. Sci. Res.* A 5:572-6.

Kirk, R. L., Kirk, M., *and* Stenhouse, N. S. (1953).—Differential fertility between women of blood groups O and A. *Brit. J. Prev. Soc. Med.* 7: 1-8.

Kirk, R. L., *and* Stenhouse, N. S. (1953).—Ability to smell solutions of potassium cyanide. *Nature.* 171:698.

McIntyre, G. A. (1952).—Method for unbiased selective sampling, using ranked sets. *Aust. J. Agric. Res.* 3:385-90.

Williams, E. J. (1952).—Interpretation of interactions in factorial experiments. *Biometrika.* 39:65-81.

Williams, E. J. (1952).—Some exact tests in multivariate analysis. *Biometrika.* 39:17-31.

Williams, E. J. (1952).—Use of scores for the analysis of association in contingency tables. *Biometrika.* 39:274-89.

Williams, E. J., *and* Kloot, N. H. (1953).—Interpolation in a series of correlated observations. *Aust. J. Appl. Sci.* 4:1-17.

20. SECTION OF METEOROLOGICAL PHYSICS.

Deacon, E. L. (1953).—Wind profiles and the shearing stress. *Quart. J. R. Met. Soc.* 79:164-6.

Deacon, E. L. (1953).—Climatic change in Australia since 1880. *Aust. J. Phys.* 6:209-18.

James, R. W. (1951).—The hurricane. *Sci. News, Harmondsworth.* No. 22:89-97.

Priestley, C. H. B. (1952).—Atmospheric turbulence in the boundary layer. U.S. Air Force Geophys. Res. Paper No. 19.

Priestley, C. H. B., *and* Sheppard, P. A.* (1952).—Turbulence and transfer processes in the atmosphere. *Quart. J. R. Met. Soc.* 78:488-529.

Samuel, D. R. (1952).—A record of the micro-structure of a cold front. *Quart. J. R. Met. Soc.* 78:616-20.

Swinbank, W. C. (1952).—The criterion of atmospheric turbulence. *Quart. J. R. Met. Soc.* 78: 420-2.

Swinbank, W. C. (1952).—The measurement of the vertical transfer of heat, water vapour and momentum by eddies in the lower atmosphere, with some results. U.S. Air Force Geophys. Res. Paper No. 19.

Taylor, R. J. (1952).—Locally isotropic turbulence in the lower layers of the atmosphere. U.S. Air Force Geophys. Res. Paper No. 19.

---

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21. Division of Metrology.

Bruce, C. F., *and* Cuninghame, W. A. F. (1952).—Calibration of standards of angle by interferometry. *Aust. J. Appl. Sci.* 3: 210-8.

Bruce, C. F., Macinante, J. A., *and* Kelly, J. C. (1953).—Calibration of sensitive vibrometers by interferometry. *Aust. J. Appl. Sci.* 4: 28-46.

Gilet, P. M., *and* Watson, G. S. (1953).—Calculation of accuracy of results of graphical square intercomparisons. *Aust. J. Phys.* 6: 155-70.

Gladman, C. A. (1952).—Some recent overseas developments in surface finish. *A'asian. Engr.* 1952 (8): 61-71.

Macinante, J. A. (1953).—Electromagnetic vibration pick-ups with simple seismic suspension. *J. Sci. Instrum.* 30: 155-8.

Macinante, J. A., *and* Dollar, W. (1953).—Stroboscopic images and the determination of angular speed. *Engineering, Lond.* 175: 132-5.

Macinante, J. A., *and* Peres, N. J. C. (1953).—Diamond pyramidal hardness testing of spherical specimens. C.S.I.R.O. Aust. Div. Metrology Tech. Paper No. 1: pp. 11.

Macinante, J. A. (1953).—Adjustable mount using differential screws. *J. Sci. Instrum.* 30: 98-9.

Peres, N. J. C. (1952).—Nomogram for mean radius of curvature of helical tooth flanks. *Engineering, Lond.* 174: 235.

Ross, H. A. (1952).—A note on the design of single phase transductors. *Aust. J. Appl. Sci.* 3: 277-92.

Ross, H. A., *and* Gore, G. W. (1953).—Design and operation of an electronic temperature controller. C.S.I.R.O. Aust. Div. Metrology Tech. Paper No. 2: pp. 31.

22. Mineragraphic Investigations.

Edwards, A. B. (1952).—Ore minerals and their textures. *J. Roy. Soc. N.S.W.* 85: 26-46.

Stillwell, F. L. (1952).—Uraninite from Rum Jungle and Fergusson River, Northern Territory. In "Sir Douglas Mawson Anniversary Volume": pp. 161-6. (Univ. Adelaide: Adelaide.)

Stillwell, F. L. (1952).—Petrology of the Tumby Bay talc deposits. Bull. Geol. Surv. S. Aust. No. 26, pp. 31-49.

Stillwell, F. L., *and* Edwards, A. B. (1952).—Petrology of the Gumeracha talc deposits. Bull. Geol. Surv. S. Aust. No. 26, pp. 31-49.

Stillwell, F. L., *and* Edwards, A. B. (1952).—Petrology of the Mount Fitton talc deposits. Bull. Geol. Surv. S. Aust. No. 26, pp. 101-8.

The following articles have been published in "Geology of Australian Ore Deposits", Pubn. 5th Emp. Min. Metall. Cong., Australia and New Zealand, 1953, 1:—

Edwards, A. B.—Mount Oxide copper mine, pp. 391-5.

Edwards, A. B.—Mineralogy of the Middleback iron ores, pp. 464-72.

Edwards, A. B., *and* Wade, M. L.—Conrad lodes, pp. 950-4.

Stillwell, F. L.—Tellurides in Western Australia, pp. 119-27.

Stillwell, F. L.—Mineralogy of the Broken Hill lode, pp. 601-26.

Stillwell, F. L.—Formation of Bendigo quartz reefs, pp. 1028-33.

Stillwell, F. L.—Costerfield gold-antimony mine, pp. 1096-100.

23. Oenological Research.

Fornachon, J. C. M. (1953).—"Studies on the Sherry Flor". (Australian Wine Board: Adelaide.)

Fornachon, J. C. M. (1953).—The accumulation of acetaldehyde by suspensions of yeasts. *Aust. J. Biol. Sci.* 6: 222-33.

Rankine, B. C. (1953).—Influence of pycnometer design on its use in determining the alcohol content of wine. *Aust. Brew. Wine J.* 71 (5): 24.

24. Ore-dressing Investigations.

Blaskett, K. S. (1952).—Ore treatment at Western Australian gold mines. 9. Smelting of concentrates at Wiluna. *Chem. Engng. Min. Rev.* 44: 380-7.

Blaskett, K. S. (1952).—Ore treatment at Western Australian gold mines. 10. General review of equipment, processes and operations. *Chem. Engng. Min. Rev.* 44: 426-33.

25. Section of Physical Metallurgy.

Corbett, J. A. (1953).—The determination of magnesium and aluminium in titanium metal. *Analyst.* 78: 20-4.

Gifkins, R. C. (1953).—The influence of thallium on the creep of lead. *J. Inst. Met.* 81: 417-25.

Gifkins, R. C., *and* Kelly, J. W. (1953).—Note on the formation and development of cells in polycrystalline zinc. *Acta Metallurgica.* 1: 321-4.

Jenkins, A. E. (1952).—Lower oxides of titanium. *Metal Progr.* 62 (11): 108-9.

Worner, H. W. (1952).—Technology of titanium. *Proc. Aust. Inst. Min. Met.* Nos. 158-9: 89-104.

Worner, H. W., *and* Cordner, G. D. (1952).—The extraction of titanium. *Proc. Aust. Inst. Min. Met.* Nos. 158-9: 65-87.

26. Division of Physics.

Jefferies, J. T. (1953).—Emission of radiation from model hydrogen chromospheres. *Aust. J. Phys.* 6: 22-44.

Klemens, P. G. (1953).—The failure of Matthiessen's rule for heavily deformed alloys. *Aust. J. Phys.* 6: 122-3.

Krishman, Sir K. S.,* *and* Klemens, P. G. (1952).—The temperature variation of the thermodynamic potential of a degenerate electron gas. *Phil. Mag.* 43: 1224-5.

Steel, W. H. (1952).—Calcul de la répartition de la lumière dans l'image d'une ligne. *Rev. Opt.* 31: 334-40.

Steel, W. H. (1952).—Etude des effects combinés des aberrations et d'une obturation centrale de la pupille sur le contraste des images optiques. Application aux objectifs de microscope à miroirs. Parts 1 and 2. *Rev. Opt.* 32: 4-26, 143-78.

Steel, W. H. (1953).—Tolerances relatives à une pupille annulaire et leur application aux microscopes à miroirs. *J. Phys. Radium.* 14 (1): 76s.

Wylie, R. G. (1952).—The properties of liquid phase embryos at the intersections of plane solid surfaces. *Aust. J. Sci. Res.* A 5: 618-27.

Wylie, R. G. (1952).—The condensation of a vapour at a crystalline surface. *Aust. J. Sci. Res.* A 5: 628-46.

---

* National Physical Laboratory, India.

27. Plant Fibre Section.

Couchman, Jean F. (1953).—The relation of the water-soluble materials to the spinning quality of flax fibre. *Aust. J. Appl. Sci.* 4:118-35.

Greenhill, W. L. (1953).—Kenaf—properties of fibre produced in Australian territories. *Textile J. Aust.* 28:444, 446, 462-3.

Greenhill, W. L., *and* Chase, G. A. (1953).—Australian woods for textile rollers—some experiments on a flax spinning system. *Wood.* 18:12-14.

28. Division of Plant Industry.

Anderson, A. J. (1952).—The significance of sulphur deficiency in Australian soils. *J. Aust. Inst. Agric. Sci.* 18:135-9.

Anderson, A. J. (1952).—Responses of subterranean clover and lucerne to boron. *J. Aust. Inst. Agric. Sci.* 18:159-62.

Anderson, A. J., *and* Arnot, R. H. (1953).—Fertilizer studies on basaltic red loam soil from the Lismore district, New South Wales. *Aust. J. Agric. Res.* 4:29-43.

Bailey, E. T. (1952).—Agronomic studies of vetches and other large-seed legumes in southern Western Australia. C.S.I.R.O. Aust. Div. Plant Industry Tech. Paper No. 1.

Ballard, L. A. T. (1952).—Coloured "Perspex" for darkroom lights. *Nature.* 170:840.

Barley, K. P. (1953).—Structure building in palomorphic soils. *J. Aust. Inst. Agric. Sci.* 19:99.

Biddiscombe, E. F. (1953).—A survey of the natural pastures of the Trangie district, New South Wales, with particular reference to the grazing factor. *Aust. J. Agric. Res.* 4:1-28.

Bisset, W. J., *and* Andrew, C. S. (1953).—The effect of nitrogen on the yield, nitrogen content and baking quality of wheat grown on the Darling Downs, Queensland. *J. Aust. Inst. Agric. Sci.* 19:40-4.

Burbidge, N. T. (1952).—The significance of the Mallee habit in eucalyptus. *Proc. Roy. Soc. Qd.* 62:72-8.

Burbidge, N. T. (1953).—The genus *Triodia* R.Br. (Gramineae). *Aust. J. Bot.* 1:121-84.

Christian, C. S., *and* Shaw, N. H. (1952).—A study of two strains of Rhodes grass (*Chloris gayana* Kunth.) and of lucerne (*Medicago sativa* L.) as components of a mixed pasture at Lawes in south-east Queensland. *Aust. J. Agric. Res.* 3:277-99.

de Plater, C. V. (1952).—A radio-frequency soil moisture meter. *J. Aust. Inst. Agric. Sci.* 18:224.

Dick, A. T., Moore, C. W. E., *and* Bingley, J. B. (1953).—The copper and molybdenum contents of some pasture species in the Murray Valley. *Aust. J. Agric. Res.* 4:44-51.

Greenham, C. G. (1952).—Phytotoxicity of histamine, arsenic acid, and dichlorophenoxyacetic acid and methods of testing. *Nature.* 170:535.

Greenham, C. G., Norris, D. O., *and* Brock, R. D. (1952).—Some electrical differences between healthy and virus-infected potato tubers. *Nature.* 169:973.

Hely, F. W., Bonnier, C., *and* Manil, P. (1952).—Essai d'adaptation à *Soya hispida* de souches de *Rhizobium* non spécifiques. Influence de greffes sur la spécificité d'hôte du genre *Rhizobium*. *Bull. Inst. Agron. Gembloux.* 20:137-40.

Hely, F. W., Bonnier, C., *and* Manil, P. (1953).—Effect of grafting on nodulation of Trifolium ambiguum. *Nature.* 171:884-5.

Hely, F. W., *and* Hudson, W. J. C. (1952).—Comparative hay yields of various annual medics in the year of establishment. *J. Aust. Inst. Agric. Sci.* 18:102-4.

Hill, A. V. (1952).—The tobacco industry in Australia. *Econ. Bot.* 6:151-9.

Hutton, E. M. (1952).—Some aspects of virus Y resistance in the potato (*Solanum tuberosum*). *Aust. J. Agric. Res.* 3:362-71.

Hutton, E. M., *and* Peak, A. R. (1953).—Spotted-wilt development in resistant and susceptible *Lycopersicon* species. *Aust. J. Agric. Res.* 4:160-7.

Johanson, R. (1953).—Interference of pentose in the estimation of hexose sugar with anthrone. *Nature.* 171:176-7.

Johanson, R. (1953).—Differential fluorescence in identification of tobacco trashy leaf. *Nature.* 171:753-4.

Kefford, N. P., *and* Bennet-Clark, T. A. (1953).—Chromatography of the growth substances in plant extracts. *Nature.* 171:645.

Lovett, W. J. (1953).—Water requirements of tobacco grown under irrigation at Clare, north Queensland. *Aust. J. Agric. Res.* 4:168-76.

McLachlan, K. D. (1953).—Effects of lime and copper on subterranean clover grown on acid soil. *Aust. J. Agric. Res.* 4:151-9.

Martin, D., *and* Lewis, T. L. (1952).—Physiology of growth in apple fruits. III. Cell characteristics and respiratory activity of light and heavy crop fruits. *Aust. J. Sci. Res.* B 5:315-27.

Moore, C. W. E. (1952).—Note on pasture classification. In "Ecological classification and nomenclature", by N. C. W. Beadle and H. B. Costin. *Proc. Linn. Soc. N.S.W.* 77:61-82.

Moore, R. M. (1952).—Weeds research in Australia. In "Abstracts and News Summary". (Fungicide and Insecticide Research Co-ordination Service.) No. 5, Aug., 1952.

Myers, L. F. (1952).—The toxicity of oil herbicides to *Paspalum dilatatum* Poir.: effect of composition of the oil. *Aust. J. Agric. Res.* 3:372-84.

Myers, L. F. (1953).—The toxicity of oil herbicides to *Paspalum dilatatum* Poir. II. The effect of light on toxicity. *Aust. J. Agric. Res.* 4:177-83.

Myers, L. F., *and* Moore, R. M. (1952).—The effect of fertilizers on a winter weed population. *J. Aust. Inst. Agric. Sci.* 18:152-5.

Rossiter, R. C. (1952).—Phosphorus toxicity in subterranean clover and oats grown on Muchea sand and the modifying effects of lime and nitrate-nitrogen. *Aust. J. Agric. Res.* 3:227-43.

Rossiter, R. C. (1952).—Studies on the nutrition of pasture plants of the south-west of Western Australia. IV. The growth of subterranean clover (*Trifolium subterraneum* L.) as affected by lime, molybdenum, and potassium. *Aust. J. Agric. Res.* 3:244-58.

Steinbergs, A. (1953).—A rapid turbidimetric method for the determination of small amounts of sulphur in plant material. *Analyst.* 78:47-53.

Thomas, L. A. (1953).—Stock and scion investigation. VII. A nursery trial with clonal pear stocks. *J. Hort. Sci.* 28:121.

Thomas, L. A. (1953).—Stock and scion investigations. VIII. A pruning and stock trial with apple trees. *J. Hort. Sci.* 28:125.

Tisdall, A. L. (1952).—Factors affecting the use of a probe in an irrigated soil. *J. Aust. Inst. Agric. Sci.* 18:156-8.

Webb, L. J. (1952).—Nitrate content and toxicity of Queensland plants. *J. Aust. Inst. Agric. Sci.* 18:164-7.

Webb, L. J. (1953).—An occurrence of aluminium succinate in *Cardwellia sublimus* F. Muell. *Nature.* 171:656.

Williams, C. H., *and* Moore, C. W. E. (1952).—The effect of stage of growth on the copper, zinc, manganese and molybdenum contents of Algerian oats grown on thirteen soils. *Aust. J. Agric. Res.* 3 : 343-61.

Williams, C. H., *and* Woodroffe, K. (1953).—The residual effect of superphosphate in soils cultivated for wheat in South Australia. *Aust. J. Agric. Res.* 4 : 127-50.

29. POLLEN RESEARCH UNIT, DEPARTMENT OF BOTANY, UNIVERSITY OF MELBOURNE.

Cookson, Isobel C. (1952).—The identification of Tertiary pollen grains with those of New Guinea and New Caledonian beeches. *Nature.* 170 : 127.

Cookson, Isobel C. (1953).—The identification of the sporomorph *Phyllocladidites* with *Dacrydium* and its distribution in southern Tertiary deposits. *Aust. J. Bot.* 1 : 64-70.

Cookson, Isobel C. (1953).—Records of the occurrence of *Botryococcus Braunii, Pediastrum* and the *Hystrichosphaerideae* in Cainozoic deposits of Australia. Mem. Nat. Mus. No. 18 : 107-23.

Cookson, Isobel C., *and* Clifford, H. T. (1953).—*Muscites Yallournensis,* a fossil moss capsule from Yallourn, Victoria. *Bryologist.* 56 : 53.

Cookson, Isobel C., *and* Pyke, Kathleen, M. (1953).—The Tertiary occurrence and distribution of *Podocarpus* (section *Dacrycarpus*) in Australia and Tasmania. *Aust. J. Bot.* 1 : 71-82.

30. DIVISION OF RADIOPHYSICS.

Beard, M., *and* Pearcey, T. (1952).—An electronic computer. *J. Sci. Instrum.* 29 : 305.

Bowen, E. G. (1952).—Australian experiments in artificial rainmaking. *Bull. Amer. Met. Soc.* 33 : 244.

Bowen, E. G. (1952).—Australian experiments in artificial stimulation of rainfall. *Weather.* 7 : 204.

Bracewell, R. N. (1952).—Theory of formation of an ionospheric layer below *E* layer based on eclipse and solar flare effects at 16 kc/s. *J. Atmos. Terr. Phys.* 2 : 226. (The work described in this paper was carried out partly at the Cavendish Laboratory, Cambridge.)

Bracewell, R. N. (1953).—The sunspot number series. *Nature.* 171 : 649.

Bracewell, R. N., *and* Bain, W. C. (1952).—An explanation of radio propagation at 16 kc/s in terms of two layers below *E* layer. *J. Atmos Terr. Phys.* 2 : 216. (The work described in this paper was was carried out partly at the Cavendish Laboratory, Cambridge.)

Christiansen, W. N. (1953).—A high resolution aerial developed for use in radio astronomy. *Nature.* 171 : 831.

Christiansen, W. N., *and* Hindman, J. V. (1952).—A preliminary survey of 1,420 Mc/s line emission from galactic hydrogen. *Aust. J. Sci. Res.* A 5 : 437.

Christiansen, W. N., *and* Hindman, J. V. (1952).—21-centimetre line radiation from galactic hydrogen. *Observatory.* 72 : 149.

Christiansen, W. N., *and* Warburton, J. A. (1953).—The distribution of radio brightness over the solar disk at a wavelength of 21 centimetres. I. A new highly-directional aerial system. *Aust. J. Phys.* 6 : 190.

Day, G. A. (1953).—Radar observations of rain at Sydney, New South Wales. *Aust. J. Phys.* 6 : 229.

Labrum, N. R. (1952).—Some experiments on centimetre-wavelength scattering by small obstacles. *J. Appl. Phys.* 23 : 1320.

Labrum, N. R. (1952).—The scattering of radio waves by meteorological particles. *J. Appl. Phys.* 23 : 1324.

Mills, B. Y. (1952).—The positions of six discrete sources of cosmic radio radiation. *Aust. J. Sci. Res.* A 5 : 456.

Mills, B. Y. (1952).—Apparent angular sizes of discrete radio sources. Observations at Sydney. *Nature.* 170 : 1061.

Pearcey, T. (1952).—An automatic computer in Australia. *Math. Tab., Wash.* 6 : 167.

Piddington, J. H. (1953).—Thermal theories of the high-intensity components of solar radio-frequency radiation. *Proc. Phys. Soc. Lond.* 66 : 97.

Piddington, J. H., *and* Davies, R. D. (1953).—The origin of the solar corona. *Nature.* 171 : 692.

Squires, P. (1952).—The growth of cloud drops by condensation. II. The formation of large cloud drops. *Aust. J. Sci. Res.* A 5 : 473.

Squires, P., *and* Gillespie, C. A. (1952).—A cloud droplet sampler for use on aircraft. *Quart. J. R. Met. Soc.* 78 : 387.

Twomey, S. (1953).—On the measurement of precipitation by radar. *J. Met.* 10 : 66.

Warner, J., *and* Bowen, E. G. (1953).—A new method of studying the fine structure of air movements in the free atmosphere. *Tellus.* 5 : 36.

31. RADIO RESEARCH BOARD.

Baker, W. G., *and* Martyn, D. F. (1953).—The conductivity of the ionosphere. *Nature.* 170 : 1090.

Ellis, G. R. (1953).—Angle of arrival of *Z* echoes. *Nature.* 171 : 258.

Kirkpatrick, C. B. (1952).—On current systems proposed for *SD* in the theory of magnetic storms. *J. Geophys. Res.* 57 : 511-26.

Martyn, D. F. (1953).—Geo-morphology of F_2 region ionospheric storms. *Nature.* 171 : 14-16.

Martyn, D. F. (1953).—The morphology of the ionospheric variations associated with magnetic disturbances. I. Variations at moderately low latitudes. *Proc. Roy. Soc.* A 218 : 1-18.

Munro, G. H. (1953).—Travelling disturbances in the ionosphere—diurnal variation of direction. *Nature.* 171 : 693.

Strohfeldt, M., McNicol, R. W. E., *and* Gipps, G. de V. (1952).—Ionospheric measurements at oblique incidence over eastern Australia. *Aust. J. Sci. Res.* A 5 : 464-72.

32. DIVISION OF SOILS.

Aitchison, G. D. (1953).—Soil moisture in engineering investigations. *Common. Engr.* 40 : 336-8.

Aitchison, G. D., *and* Holmes, J. W. (1953).—Aspects of swelling in the soil profile. *Aust. J. Appl. Sci.* 4 : 244-59.

Aitchison, G. D., *and* Holmes, J. W. (1953).—Seasonal changes of soil moisture in a red-brown earth and a black earth in southern Australia. *Aust. J. Appl. Sci.* 4 : 260-73.

Brown, G., *and* Norrish, K. (1952).—Hydrous micas. *Min. Mag.* 29 : 929-32.

Butler, B. E., *and* Brewer, R. (1952).—Soils of the Abermusden Irrigation Area. C.S.I.R.O. Aust. Div. Soils, Soils and Land Use Series, No. 9.

David, D. J., *and* Oertel, A. C. (1953).—A trial of statistical techniques in assessing spectrographic influence of basic composition. *Aust. J. Appl. Sci.* 4 : 235.

Gurr, C. G., Marshall, T. J., *and* Hutton, J. T. (1952).—Movement of water in soil due to a temperature gradient. *Soil Sci.* 74:335-45.

Johnston, E. J. (1953).—Pedology of Deniboota Irrigation District. C.S.I.R.O. Aust. Soil Publication No. 1.

Stephens, C. G. (1953).—"A Manual of Australian Soils." (C.SI.R.O.: Melbourne.)

33. Division of Tribophysics.

Boas, W. (1953).—The metal physics work of the Division of Tribophysics, C.S.I.R.O. *Nature.* 171:908.

Boas, W., *and* Nicholas, J. F. (1953).—Validity of Matthiessen's rule for cold-worked wires. *Aust. J. Phys.* 6:116.

Broom, T. (1952).—The effect of temperature of deformation on the electrical resistivity of cold-worked metals and alloys. *Proc. Phys. Soc. Lond.* B 65:871.

Clarebrough, L. M., Hargreaves, M. E., Michell, D., *and* West, G. W. (1952).—The determination of the energy stored in a metal during plastic deformation. *Proc. Roy. Soc.* A 215:507.

Greenhill, E. B., *and* McDonald, S. R. (1953).—The surface free energy of solid paraffin wax. *Nature.* 171: 377.

Moore, A. J. W. (1952).—Accommodation kinking associated with the twinning of zinc. *Proc. Phys. Soc. Lond.* B 65:956.

Mulcahy, M. F. R., *and* Watt, I. C. (1953).—The kinetics of oxidation of benzaldehyde. I. Survey of the reaction in solution. *Proc. Roy. Soc.* A 216:10.

Mulcahy, M. F. R., *and* Watt, I. C. (1953).—The kinetics of oxidation of benzaldehyde. II. The kinetics of the uncatalysed reaction in solution. *Proc. Roy. Soc.* A 216:30.

Nicholas, J. F. (1953).—Effect of the Fermi energy on the stability of superlattices. *Proc. Phys. Soc. Lond.* A 66:201.

Ogilvie, G. J. (1953).—The continuity of slip lines across a grain boundary. *J. Inst. Met.* 81:491.

Vines, R. G. (1953).—The thermal conductivity of organic vapours. The influence of molecular interaction. *Aust. J. Chem.* 6:1.

34. Wildlife Survey Section.

Frith, H. J. (1952).—Notes on the pigeons of the Richmond River, New South Wales. *Emu.* 52:89-101.

Myers, K. (1952).—Oviposition and mating behaviour of the Queensland fruit-fly (*Dacus* (*Strumeta*) *tryoni* (Frogg.)) and the solanum fruit-fly (*Dacus* (*Strumeta*) *cacuminatus* (Hering.)). *Aust. J. Sci. Res.* B:264-81.

Myers, K. (1952).—Rhythms in emergence and other aspects of behaviour of the Queensland fruit-fly (*Dacus* (*Strumeta*) *tryoni*, Frogg.) and the solanum fruit-fly (*Dacus* (*Strumeta*) *cacuminatus*, Hering.)). *Aust. J. Sci.* 15:101-2.

Serventy, D. L. (1952).—Size of the rock python. *W.A. Naturalist.* 3 (7):171-2.

Serventy, D. L. (1953).—The southern invasion of northern birds during 1952. *W.A. Naturalist.* 3 (8):177-96.

Serventy, D. L. (1953).—Some speciation problems in Australian birds: with particular reference to the relations between Bassian and Eyrean "species-pairs". *Emu.* 53 (2):131-45.

35. Wool Textile Research Laboratories.

Crewther, W. G. (1953).—Studies on *Aerobacillus polymyxa.* IV. Factors affecting the production of hydrogenase and the hydrogenlyase systems. *Aust. J. Biol. Sci.* 6:190.

Crewther, W. G. (1953).—Studies on *Aerobacillus polymyxa.* V. The significance of the Michaelis constants of the hydrogenlyase systems and related enzymes. *Aust. J. Biol. Sci.* 6:198.

Crewther, W. G. (1953).—Studies on *Aerobacillus polymyxa.* VI. Some properties of the hydrogenlyase systems of bacteria. *Aust. J. Biol. Sci.* 6:205.

Crewther, W. G., *and* Pressley, T. A. (1953).—Fellmongering investigations. XVII. Improved water digestion of sheepskin pieces by aeration and the addition of calcium. *Aust. J. Appl. Sci.* 4:344.

Jermyn, M. A. (1953).—Fungal cellulases. I. General properties of unpurified enzyme preparations from *Aspergillus oryzae.* *Aust. J. Sci. Res.* B 5:409.

Jermyn, M. A. (1953).—Fungal cellulases. II. The complexity of enzymes from *Aspergillus oryzae* that split β-glucosidic linkages and their partial separation. *Aust. J. Sci. Res.* B 5:433.

Jermyn, M. A. (1953).—Fungal cellulases. III. *Stachybotrys atra*: growth and enzyme production on non-cellulosic substrates. *Aust. J. Biol. Sci.* 6:48.

Jermyn, M. A. (1953).—Factors influencing the paper chromatography of some enzymes of *Aspergillus oryzae* and related enzymes. *Aust. J. Biol. Sci.* 6:77.

Jermyn, M. A., *and* Thomas, R. (1953).—Transferase activity of the β-glucosidases of *Aspergillus oryzae.* *Aust. J. Biol. Sci.* 6:70.

Leach, S. J. (1953).—The rate of hydrolysis of proteins and peptides. *Rev. Pure Appl. Chem.* 3:25.

Leach, S. J., *and* Lindley, H. (1953).—Structure of asparagine. *Nature.* 171:1062.

Lennox, F. G., *and* Forss, H. M. (1952).—Effect of tanning in protecting collagen against enzyme digestion. *J. Soc. Leath. Tr. Chem.* 36:322.

Lennox, F. G., *and* Forss, H. M. (1953).—Further studies on the digestion of wool keratin in papain-urea: the effect of adding compounds that rupture disulphide bonds in alkaline solution. *Aust. I. Biol. Sci.* 6:118.

O'Donnell, I. J., *and* Swan, J. M. (1953).—The apparent degradation of wool by diazomethane solutions. *Nature.* 171:571.

Swan, J. M. (1952).—Thiohydantoins. I. The preparation of some 2-thiohydantoins from amino acids and acylamino acids. *Aust. J. Sci. Res.* A 5:711.

Swan, J. M. (1952).—Thiohydantoins. II. Thiohydantoins derived from aspartic and glutamic acids. *Aust. J. Sci. Res.* A 5:721.

Swan, J. M. (1952).—Thiohydantoins. III. Anhydride intermediates in the formation of 1-acyl-2-thiohydantoins from acylamino acids. *Aust. J. Sci. Res.* A 5:728.

Woods, E. F. (1952).—The viscosity of urea solutions of keratin. *Aust. J. Sci. Res.* A 5:555.

Woods, E. F., *and* Gillespie, J. M. (1953).—A critical study of the use of paper electrophoresis for separating proteins and measuring their isoelectric points. *Aust. J. Biol. Sci.* 6:130.

Woods, E. F., *and* Ogston, A. G. (1953).—Molecular configuration of dextrans in aqueous solution. *Nature.* 171:221.

XXXVI.—FINANCE.

1. Expenditure.

The statement of expenditure from July 1, 1952, to June 30, 1953, is as follows:—

	£	£	£
(*a*) Salaries and contingencies			236,415*
(*b*) Investigations—			
(i) Animal Health and Production Problems		493,656	
Less contributions from—			
Wool Industry Fund	44,772		
Wool Research Trust Account	122,441		
Commonwealth Bank	500		
Australian Dairy Produce Board	2,500		
Australian Meat Board	32,434		
Australian Wool Board (Balance of old grants)	275		
Ian McMaster Bequest	3,060		
Burdekin Bequest (Drought feeding)	1,503		
Department of Territories	8,637		
Wool Revenue Funds—			
Regional Pastoral Laboratory, Armidale	12,474		
Deniliquin Strain Trials	668		
Special Revenue Funds—			
Burdekin Bequest	1,734		
Gilruth Plains Field Station	23,799		
		254,797	
			238,859
(ii) Biochemistry and General Nutrition Problems		92,274	
Less contributions from—			
Wool Research Trust Account	30,751		
Wool Industry Fund	1,166		
Wool Revenue Funds—Glenthorne Field Station	2,443		
		34,360	
			57,914
(iii) Plant Problems—Division of Plant Industry		441,442	
Less contributions from—			
Wool Industry Fund	9,364		
Wool Research Trust Account	64,776		
Wool Revenue Funds—			
Glen Lossie Field Station	3,059		
Deniliquin Field Station	11,496		
		88,695	
			352,747
(iv) Entomology Problems		130,830	
Less contributions from—			
Australian Meat Board	389		
		389	
			130,441
(v) Soils and Irrigation Problems of Irrigation Settlements—			
(*a*) Citricultural—Research Station, Griffith		47,618	
Less contributions from—			
New South Wales Water Conservation and Irrigation Commission	2,000		
Special Revenue Fund—Griffith Research Station	787		
		2,787	
			44,831
(*b*) Viticultural—Research Station, Merbein		47,410	
Less contributions from—			
Dried Fruits Control Board	1,600		
Mildura Co-op. Fruit Company	250		
Irymple Packing Company	250		
Red Cliffs Co-op. Fruit Company	250		
Aurora Packing Company	250		
Co-op. Dried Fruit Sales Ltd.	250		
Nyah-Woorinen Enquiry Committee	130		
		2,980	
			44,430
			89,261
(vi) Soil Problems			117,829
Unapportioned overseas expenditure on Soils and Irrigation Investigations			119
(vii) Food Preservation and Transport Problems		161,858	
Less contributions from—			
Commonwealth Bank	1,000		
New South Wales Department of Agriculture	1,919		
Metropolitan Meat Industry Commission	500		
Queensland Meat Industry Board	850		
Australian Meat Board	1,125		
Australian Egg Board	750		
Batlow Packing Company	49		
William Angliss Ltd.	399		
Vita Foods Ltd.	102		
Department of Commerce and Agriculture	2,600		
Cottee's Passiona Ltd.	44		
Lewis Berger	100		
Various Contributors	400		
		9,838	
			152,020

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* The main items of expenditure under this heading are salaries of the Administrative Staff at the Organization's Head Office; salaries and expenses of officers at the Liaison Offices in London and Washington; staff and upkeep of State Committees; travelling expenses of Head Office Staff; and general office expenditure.

	£	£	£
(viii) Forest Products Problems	..	225,664	
Less contributions from—			
Australian Paper Manufacturers Limited	591		
Associated Pulp and Paper Mills Limited	500		
Australian Newsprint Mills	500		
New Zealand Forest Products Limited	250		
Victorian Railways	197		
Department of Territories	2,191		
General Donations	189		
		4,418	
			221,246
(ix) Mining and Metallurgy	..	23,074	
Less contributions from—			
Australian Institute of Mining and Metallurgy	500		
		500	
			22,574
(x) Radio Research	..	33,131	
Less contributions from—			
Postmaster-General's Department	8,250		
Department of Supply	16,500		
		24,750	
			8,381
(xi) Research Services	..	181,947	
Less contributions from—			
Wool Research Trust Account	3,304		
Australian Dried Fruits Association	1,500		
		4,804	
			177,143
(xii) Industrial Chemistry	..	304,408	
Less contributions from—			
National Gas Association	600		
Cement and Concrete Association	1,500		
		2,100	
			302,308
(xiii) Fisheries Investigations	...	150,361	
Less contributions from—			
New South Wales Government	250		
		250	
			150,111
(xiv) Mathematical Statistics	..	..	39,005
(xv) National Standards Laboratory	..	..	363,252
(xvi) Tribophysics	..	..	58,384
(xvii) Building Research	..	..	110,259
(xviii) Plant Fibre Research	..	..	31,850
(xix) Radiophysics Research	..	..	218,287
(xx) Metallurgical Research	..	..	7,667
(xxi) Nuclear Energy Research	..	..	46,592
(xxii) Meteorological Physics	..	..	42,552
(xxiii) Dairy Research	..	...	28,450
(xxiv) Wool Textile Research	..	229,375	
Less contributions from—			
Wool Research Trust Account	166,859		
Wool Industry Fund	54,987		
Department of Supply	1,000		
Associated Woollen Worsted Textile Manufacturers of Australia	1,325		
		224,171	
			5,204
(xxv) Fuel Research	..	128,894	
Less contributions from—			
Joint Coal Board	22,000		
		22,000	
			106,894
(xxvi) Wildlife Survey	..	37,644	
Less contributions from—			
George Aitken Pastoral Research Trust	1,000		
Wool Research Trust Account	16,300		
		17,300	
			20,344
(xxvii) Land Research and Regional Survey	..	73,688	
Less contributions from—			
Department of National Development	17,058		
Department of Territories	10,485		
		27,543	
			46,145
(xxviii) Genetics	..	26,937	
Less contributions from—			
Wool Research Trust Account	10,306		
Commonwealth Bank	1,001		
		11,307	
			15,630
(xxix) Miscellaneous—			
(*a*) Biophysical Research	..	1,893	
(*b*) Oenological Research	..	3,951	
(*c*) Various	..	1,519	
		7,363	
Less contributions from—			
Australian Wine Board	1,975		
Science and Industry Endowment Fund	665		
		2,640	
			4,723

	£	£	£
(xxx) Unforeseen and Urgent	..	..	—
Total of Item (*b*)—Investigations	..	..	3,166,191
(*c*) Grants—			
(i) Research Associations—			
Leather Research Association	6,532		
Bread Research Institute	5,000		
		11,532	
(ii) Overseas Research Studentships	..	26,280	
		37,812	
Less contributions from—			
Wool Research Trust Account	5,356		
Science and Industry Endowment Fund	1,706		
		7,062	
			30,750
Total Salaries and Contingencies, Investigations and Grants	..	..	3,433,356

2. CONTRIBUTIONS AND DONATIONS.

The following statement shows the receipts and disbursements during the year 1952-53 of the funds provided by outside bodies and recorded in the special account entitled "The Specific Research Fund" (formerly "The Specific Purposes Trust Account"):—

	Receipts 1952-53 and balances brought forward from 1951-52.	Expenditure 1952-53.
	£	£
Wool Industry Fund Account	330,779	327,283*
Commonwealth Bank (Animal Health and Production, Food Preservation and Transport, and Genetics Investigations)	4,594	2,501
Australian Wool Board (Animal Health and Production Investigations—Sheep Research)	1,672	275
Australian Dairy Produce Board (Mastitis Investigations)	2,000	2,000
George Aitken Pastoral Research Trust (Animal Health and Production Investigations)	500	..
W. McIlrath Research Fellowship Fund (Animal Husbandry Investigations)	25,000	25,000A
Australian Meat Board (Toxaemic Jaundice Investigations, Barooga, New South Wales)	1,000	1,000
Australian Meat Board (Cattle Breeding Investigations)	29,472	28,952
Australian Meat Board (Caseous Lymphadenitis Investigations—Animal Health and Production)	412	..
Australian Meat Board (Beef Cattle Research)	2,082	2,082
Australian Meat Board (Bovine Pleuropneumonia Investigations)	490	400
Australian Meat Board (Parasitological Studies of Cattle)	4,000	..
Australian Dairy Produce Board (Parasitological Studies of Cattle)	2,000	..
C.P.P. Fairbairn (Animal Health and Production Investigations—Foot-rot Control)	30	..
Department of Territories (Importation of Cattle from Pakistan)	8,637	8,637
Estate of the late Captain Ian McMaster (Animal Health and Production Investigations)	3,742	3,742B
Australian Dairy Produce Board (Physiology Investigations)	500	500
West Australian Golf Association (Plant Industry Investigations)	51	..
United Graziers' Association of Queensland—Buffalo Fly and Cattle Tick Investigations (Entomology)	172	..
Australian Meat Board—Colloidal Dispersions Investigations (Entomology)	276	276
Australian Meat Board—Cattle Tick Investigations (Entomology)	113	113
Burdekin Bequest (Drought Feeding Investigations)	1,503	1,503
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	2,000	2,000
Mildura Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	250	250
Irymple Packing Co. (Dried Vine Fruits Investigations, Merbein)	250	250
Red Cliffs Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	250	250
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	250	250
Co-op. Dried Fruit Sales Ltd. (Dried Vine Fruits Investigations, Merbein)	250	250
Dried Fruits Control Board (Dried Fruits Investigations)	1,600	1,600
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	501	129
Australian Dried Fruits Association (Packing House Methods Investigations)	1,500	1,500
Australian Meat Board (Meat Investigations)	500	500C
Metropolitan Meat Industry Commissioners of New South Wales (Meat Investigations)	500	500
Queensland Meat Industry Board (Meat Investigations)	850	850
Department of Commerce and Agriculture (Mutton Dehydration Investigations)	2,600	2,600
New South Wales Department of Agriculture (Food Investigations)	1,000	1,000
Vita Food Supply Co. (Food Investigations)	105	102
W. Angliss Ltd. (Division of Food Preservation and Transport)	450	399
Cottee's Passiona Ltd. (Food Investigations)	50	44
L. Berger and Sons (Division of Food Preservation and Transport)	100	100
Batlow Packing House Co-op. Ltd. (Division of Food Preservation and Transport — Fruit Juice Investigations)	379	49
Various Contributors (Division of Food Preservation and Transport —Fruit Products and Canning Investigations)	125	..
Various Contributors (Division of Food Preservation and Transport — Overseas Expenses — R. S. Mitchell)	400	400
Australian Meat Board (Division of Food Preservation and Transport — Physiological Investigations)	750	750
Australian Egg Board (Division of Food Preservation and Transport—Egg Investigations)	750	750

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* For details of expenditure see page 190.

A. —This expenditure relates to the purchase of Commonwealth Inscribed Stock representing part of the capital of the Fund.

B. —Includes £682 on account of 1951–52 expenditure.

C.—Includes £125 on account of 1951–52 expenditure.

	Receipts 1952-53 and balances brought forward from 1951-52. £	Expenditure 1952-53. £
New South Wales Department of Agriculture—Quick Freezing of Fruit and Vegetables (Division of Food Preservation and Transport)	968	919
Australian Paper Manufacturers Ltd. (Paper Pulp Investigations)	1,000	591
Australian Newsprint Mills (Paper Pulp Investigations)	500	500
Associated Pulp and Paper Mills Ltd. (Paper Pulp Investigations)	500	500
New Zealand Forest Products Ltd. (Paper Pulp Investigations)	250	250
Sundry Contributors (Forest Products Investigations)	433	189
Miscellaneous Contributors (Division of Forest Products—Timber Seasoning Work)	10	..
Miscellaneous Contributors (Division of Forest Products—Veneer and Gluing Work)	8	..
Victorian Railways—High Pressure Test—Railway Sleepers (Division of Forest Products)	1,180	197
Department of Territories (Development of Pulp and Paper Industry in New Guinea)	2,305	2,191
Australian Institute of Mining and Metallurgy (Mineragraphic Investigations)	500	500
Postmaster-General's Department (Radio Research)	8,250	8,250
Department of Supply (Radio Research)	16,500	16,500
Drug Houses of Australia (Division of Fisheries—Agar Production)	25	..
Miscellaneous Contributors (Division of Industrial Chemistry)	1,275	..
Commonwealth Fertilizers and Chemicals (Industrial Chemistry)	300	..
Department of Supply (Textile Degradation Investigations)	1,000	1,000
National Gas Association (Gas Investigations — Industrial Chemistry)	1,333	600
Mt. Morgan Ltd. and Mt. Lyell Mining and Railway Co. Ltd. (Industrial Chemistry—Co-operative Investigations)	2,000	..
New South Wales Government (Fisheries Investigations)	250	250
Russell Pty. Ltd. (Crayfish Investigations—Division of Fisheries)	100	..
Crayfish Exporters Association of Australia (Crayfish Investigations—Division of Fisheries)	201	..
Australian Cement Manufacturers (Cement Investigations — Industrial Chemistry/Soils)	2,250	2,250D
Apple and Pear Board—Thrips Investigations	77	..
Sundry Contributors (Commonwealth Scientific and Industrial Research Organization—Publications)	24	..
Wool Wax Report—Royalties	5	..
Science and Industry Endowment Fund	2,373	2,373E
Miscellaneous Contributors (Mathematical Instruments Section)	80	..
Miscellaneous Contributors (Mineragraphic Investigations)	13	..
Wool Scourers, Carbonizers, and Fellmongers Federation of Australia (Wool Textile Research)	3,000	..
General Donations (Division of Building Research)	551	..
Various Contributors (Foundry Sands Investigations—Division of Industrial Chemistry)	28	..
Department of National Development — Kimberley Research Station	1,413	1,413F
Australian Wine Board—Oenological Research	2,196	1,975
Department of Territories (Tobacco Investigations)	4,082	3,364
Department of Territories (Resources Survey—Papua and New Guinea)	8,018	7,122
Department of National Development (Northern Australia Regional Survey)	16,850	16,850G
George Aitken Pastoral Research Trust—Rabbit Investigations	1,000	1,000
Associated Woollen Worsted Textile Manufacturers of Australia (Wool Textile Research)	8,102	1,325
Joint Coal Board (Coal Investigations)	24,000	22,000
Wool Revenue Fund—Regional Pastoral Laboratory, Armidale (Animal Health and Production Investigations)	12,474	12,474
Wool Revenue Fund — Strain Trials, Deniliquin (Animal Health and Production Investigations)	668	668
Wool Revenue Fund—Glenthorne Field Station (Biochemistry and General Nutrition Investigations)	2,443	2,443
Wool Revenue Fund—" Glen Lossie " Field Station, Kojonup (Plant Industry Investigations)	3,059	3,059
Wool Revenue Fund—Regional Pastoral Laboratory, Deniliquin (Plant Industry Investigations)	11,496	11,496
Special Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla (Animal Health and Production Investigations)	37,019	23,799
Special Reserve Fund—National Field Station, " Gilruth Plains ", Cunnamulla (Animal Health and Production Investigations)	15,000	..
Special Revenue Fund—Burdekin Bequest (Animal Health and Production Investigations)	1,994	1,734
Special Revenue Fund—Research Station, Griffith (Citricultural Investigations)	13,054	787
	644,592	567,356

3. WOOL RESEARCH TRUST ACCOUNT.

A credit balance of £732,305 was brought forward from 1951-52 in the Wool Research Trust Account. A further £411,033 was received during 1952-53 of which amount £338,738 was received from the Department of Commerce and Agriculture; the balance of £72,295 represented the amounts remaining in the Wool Revenue Account as at 30th June, 1953, which were transferred to the credit of the Wool Research Trust Account. Expenditure during 1952-53 was as follows:—

	£	£	£
Division of Animal Health and Production—			
Parkville—			
Sheep Physiology Investigations—Parkville	6,065		
Sheep Physiology Investigations—Tooradin	2,001		
McMaster Laboratory—			
Parasitology Investigations—New South Wales	5,274		
Parasitology Investigations—Tasmania and Western Australia	1,000		
Parasite Physiology and Toxicology	1,424		
Biochemical Investigations	3,595		
Physiology of Reproduction	2,043		
Dipping and External Parasites	1,107		
Veterinary Parasitology Laboratory, Yeerongpilly—			
Sheep Blowfly Investigations	3,595		

D.—Includes £750 on account of 1951-52 expenditure.
E.—Includes £2 on account of 1951-52 expenditure.
F.—Includes £198 on account of 1951-52 expenditure.

G.—Includes £1,007 on account of 1951-52 expenditure.

	£	£	£
Sheep Biology Laboratory, Prospect—			
Administrative and General Expenses	8,273		
Fleece Analysis	21,130		
Wool Biology Investigations	19,720		
Strain Trial Investigations	3,964		
Regional Pastoral Laboratory, Armidale—			
Parasitology, Agrostology, and Field Investigations	43,250		
		122,441	
Division of Plant Industry—			
Agrostology Investigations	59,206		
Mineral Deficiency Studies	5,571		
		64,777	
Research Services—			
Agricultural Research and Extension Liaison	3,303		
		3,303	
Division of Industrial Chemistry—			
Expenditure on Wool Textile Research—			
Chemical Physics Investigations	6,793		
Organic Chemistry Investigations	9,963		
Physical Chemistry Investigations	1,141		
Clover Infertility Tests, Western Australia	258		
		18,155	
Division of Biochemistry and General Nutrition—			
Biochemical and Nutritional Investigations	30,751		
		30,751	
Wool Textile Research Laboratories—			
Wool Textile Research	148,704		
		148,704	
Wildlife Survey Section—			
Wildlife Survey	16,300		
		16,300	
Animal Genetics Section—			
Animal Genetics Investigations	10,306		
		10,306	
Miscellaneous—			
Overseas Studentships	5,356		
		5,356	
			420,093
Grants from Wool Research Trust Account to Institutions undertaking research in Agricultural Economics relating to wool production—			
Department of Commerce and Agriculture, Bureau of Agricultural Economics	26,443		
Wool Adviser	2,274		
		28,717	
Grant from Wool Research Trust Account to Wool Realization Commission in connexion with Wool Sales Statistics	6,463		
		6,463	
			35,180
			455,273

4. Wool Industry Fund.

A credit balance of £30,629 was brought forward from 1951-52 in the Wool Industry Fund Account. A further £300,150 was received during 1952-53. Expenditure during 1952-53 amounting to £327,283 was incurred as follows:—

	£	£	£
Division of Animal Health and Production—			
Sheep Biology Laboratory, Prospect—			
Animal house No. 2 and fleece and shearing building	36,035		
Two prefabricated buildings	23,519		
Feed store, garage and workshop	20,683		
Minor works	10		
Motor vehicle	1,116		
Improvements at Deniliquin	2,113		
Equipment	14,562		
Climate Control building	11,800		
Developmental expenditure—fencing, roads, water supply, &c.	6,259		
		116,097	
Regional Pastoral Laboratory and Chiswick Field Station, Armidale—			
Annexe No. 2	1,856		
Field Laboratory	1,128		
Erection of five cottages	10,166		
Construction of small buildings and roads and provision of services	4,654		
Improvements	3,246		
Furnishings for bachelors' quarters and cottages	1,022		
		22,072	
McMaster Laboratory—			
Small animal accommodation	1,334		
		1,334	
Division of Plant Industry—			
Head-quarters, Agrostology Section, Canberra—			
Agrostology and Pasture Chemistry prefabrications	48		
		48	
Associated studies, New South Wales—			
Department of Agriculture, Trangie Field Laboratory	39		
		39	
Western Australian investigations—			
Pot culture laboratory, Crawley	2,221		
Regional laboratory, Perth	2,868		
"Glen Lossie" Field Station, Kojonup—			
Station manager's residence and staff cottages	9,540		
Erection of shearing shed and yards	1,811		
Developmental expenditure—clearing, fencing, water supply, roadways, &c.	6,308		
		22,748	
Regional Pastoral Laboratory and Falkiner Memorial Field Station, Deniliquin—			
Erection of laboratory	6,741		
Station manager's residence	2,993		
Developmental expenditure—fencing, water supply, paths, kerbs, channels, &c.	2,435		
Purchase of land	1,000		
		13,169	
Wool Textile Research—			
Melbourne—			
Conversion of "Quamby"	8,772		
Prefabricated building	6,177		
Plant	4,061		
		19,010	
Sydney—			
Conversion of "The Hermitage"	12,577		
Erection of store and plant rooms	1,906		
Erection of workshop building	4,514		
Plant	2,613		
Textile machinery	258		
		21,868	
Geelong—			
Development of site	5,835		
Laboratory and six cottages	31,907		
Textile machinery	14,480		
Plant	1,661		
		53,883	
Division of Industrial Chemistry—			
Biochemistry laboratory, Fishermen's Bend	15,041		
		15,041	
Division of Biochemistry and General Nutrition—			
Glenthorne Experimental Station—			
Sheep yards and units	1,176		
		1,176	
Grants from Wool Industry Fund for extra-mural co-operative wool research—			
Victoria—			
Melbourne University — Sheep and Wool Survey	50		
Melbourne University — Electrotype Physiology Studies	3,000		
Gordon Institute of Technology—Wool Textile Investigations	2,913		
Department of Lands and Survey—			
Myxomatosis Investigations	2,626		
		8,589	

	£	£	£
Western Australia—			
Institute of Agriculture—Animal Flora Studies	3,450		
Institute of Agriculture—Genetic Studies	1,050		
Department of Agriculture and Institute of Agriculture—Clover Infertility Investigations	2,700		
Dr. White—Clover Infertility ..	820		
		8,020	
South Australia—			
Roseworthy Agricultural College—Progeny Testing	4,185		
Waite Institute — Agrostology, Weeds and Entomology ..	6,400		
		10,585	
Queensland—			
Department of Agriculture and Stock—			
Fertility and neo-natal mortality	600		
Progeny testing and wool metrology	1,050		
Poison Plants Committee ..	300		
University of Queensland—Sheep Physiology	2,100		
		4,050	
New South Wales—			
University of Technology—Wool clip analysis	4,200		
University of Sydney—Animal physiology investigations	1,750		
Department of Agriculture—Disordered metabolism ..	1,500		
		7,450	
General—			
Wool Industries Research Association, United Kingdom	1,254		
Sheep and Wool publications	850		
		2,104	
			£327,283

5. DIVISIONAL REVENUE (EXCLUDING WOOL REVENUE AND SPECIAL REVENUE FUNDS).

The following amounts were earned by Divisions nd Sections apart from the revenue included under ection 2:—

	£	£
ivision of Animal Health and Production—		
Sale of Contagious Pleuro-Pneumonia Vaccine	6,313	
Mastitis Investigations	3,326	
Parkville Laboratory	133	
Toxaemic Jaundice Investigations, Barooga, New South Wales	715	
Toxaemic Jaundice Investigations, Parkville, Victoria	40	
Oestrus Experiments	2,001	
Poultry Breeding Investigations ..	11,422	
Contagious Pleuro-Pneumonia Investigations	1,011	
Tooradin Field Station	1,599	
Bacteriological Investigations	53	
Parasitological Investigations	1,725	
McMaster Field Station Revenue ..	3,358	
Veterinary Parasitology Laboratory ..	82	
Cobram Field Station	2,280	
ivision of Plant Industry—		
Plant Industry Investigations, Canberra	3,462	
Stanthorpe Field Station	456	
ivision of Entomology—		
Entomological Investigations	99	
erbein Research Station Revenue ..	5,770	
ivision of Food Preservation and Transport Revenue	145	
Division of Forest Products	126	
Ore Dressing Investigations	212	
Division of Industrial Chemistry—		
Industrial Chemistry Investigations ..	7	
Microanalysis Investigations	1,955	
Division of Fisheries—		
Fisheries Investigations	259	
Sale of Pearlshell	360	
Division of Metrology	1,163	
Division of Electrotechnology	529	
Division of Physics	468	
Division of Biochemistry and General Nutrition	216	
Division of Radiophysics	1,092	
Dairy Research Section	1	
Land Research and Regional Survey, Katherine	47	
Fuel Research Section	2	
Total		50,427

Of the above amount, £49,527 was spent during 1952-53; the remainder being portion of balance carried forward in the Trust Fund Science and Industry Account to 1953-54.

6. WORKS PROJECTS (UNDER CONTROL OF C.S.I.R.O.).

Expenditure on works projects from funds made available directly to C.S.I.R.O. by the Treasury is as follows:—

	£
Homebush Laboratory	1,592
Construction of Fisheries Research Vessel	1,254
	2,846

7. MISCELLANEOUS SERVICES.

Contribution to Commonwealth Agricultural Bureaux	38,437
Grant to Standards Association of Australia ..	40,000
Grant to Australian National Research Council ..	3,000
Contribution to Chair of Aeronautics at University of Sydney (establishment and maintenance) ..	5,000
Grant to National Association of Testing Authorities	8,400
International Institute of Radio Science	5,350
Australian and New Zealand Association for the Advancement of Science	1,250
	101,437

XXXVII. ACKNOWLEDGMENTS.

In various sections of this Report reference has been made as in previous years to the valuable assistance afforded by many State Departments, Universities, and other organizations and individuals. The Organization desires to express its gratitude for the help given by these bodies and persons in providing laboratory accommodation and other facilities and in many other ways. The Organization also wishes to acknowledge the assistance it has received from its Committees, the members of which have placed their knowledge and experience so freely at its disposal.

I. CLUNIES ROSS, Chairman.
F. W. G. WHITE.
S. H. BASTOW.
H. G. GOODES.
A. B. RITCHIE.
} Executive.

November, 1953.

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